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Li et al.

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(45) **Date of Patent: Aug. 23, 2016**

(54) **SYSTEMS AND METHODS FOR PREDICTING AN EXPECTED BLOCKAGE OF A SIGNAL PATH OF AN ULTRASOUND SIGNAL**

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(73) Assignee: **Qualcomm Incorporated**, San Diego, CA (US)

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Related U.S. Application Data

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(51) **Int. Cl.**

G01S 3/80	(2006.01)
G06F 3/041	(2006.01)
G06F 3/043	(2006.01)

(52) **U.S. Cl.**
CPC . ***G01S 3/80*** (2013.01); ***G06F 3/043*** (2013.01); ***G06F 3/0418*** (2013.01); ***G06F 3/0433*** (2013.01)

(58) **Field of Classification Search**
CPC G01S 11/00
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,454,714	B1	9/2002	Ng et al.
6,633,280	B1	10/2003	Matsumoto et al.
7,218,040	B2	5/2007	Toda
7,843,859	B1	11/2010	Gregorian et al.
7,852,318	B2	12/2010	Altman
2005/0054931	A1	3/2005	Clark
2006/0098810	A1	5/2006	Kim
2008/0309641	A1	12/2008	Harel et al.

(Continued)

FOREIGN PATENT DOCUMENTS

EP	1862889 A2	12/2007
JP	8044487	2/1996
JP	2001142639	5/2001

(Continued)

OTHER PUBLICATIONS

International Search Report and Written Opinion for International application No. PCT/US2012/069382 mailed Apr. 2, 2013, 13 pages.

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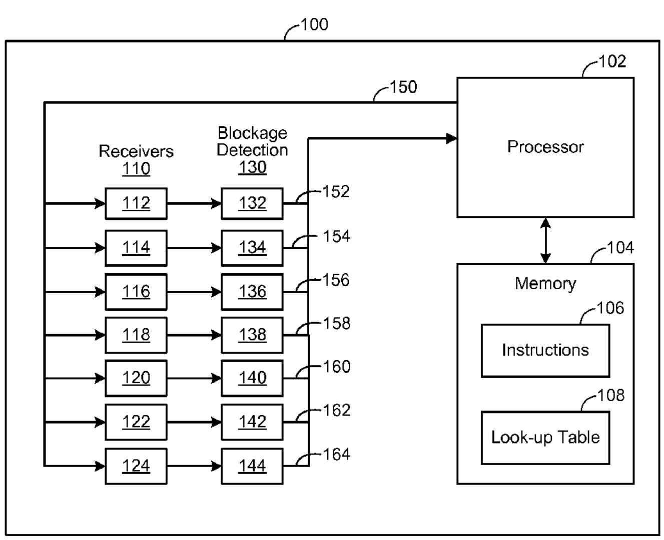
(74) *Attorney, Agent, or Firm* — Toler Law Group, PC

(57) **ABSTRACT**

A method includes detecting a signal at a first set of receivers of a plurality of receivers of a device. The plurality of receivers includes the first set of receivers and a second set of receivers. The first set of receivers corresponds to selected receivers and the second set of receivers corresponds to non-selected receivers. The method includes predicting, based on the signal, an expected blockage of a signal path between a source of the signal and a first selected receiver of the first set of receivers, and selecting a particular receiver of the second set of receivers as a newly selected receiver in response to predicting the expected blockage.

41 Claims, 23 Drawing Sheets



(56) **References Cited**

U.S. PATENT DOCUMENTS

2010/0208907	A1	8/2010	Ukai et al.	
2011/0115748	A1*	5/2011	Xu	G06F 3/0421 345/175

FOREIGN PATENT DOCUMENTS

JP	2001142640		5/2001	
WO	2005111653	A2	11/2005	
WO	WO200/5111653	*	11/2005	G01S 11/00

* cited by examiner

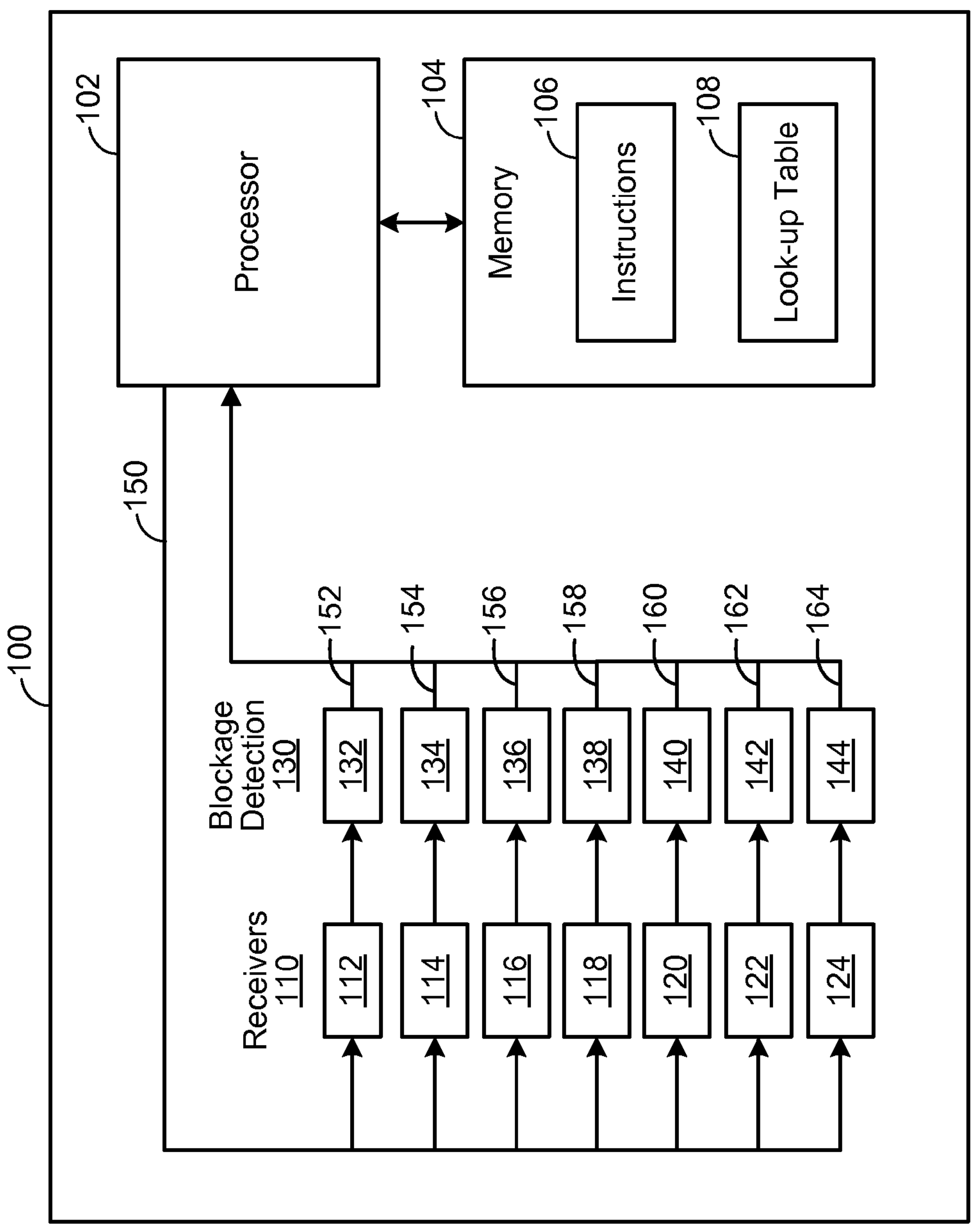

100
102
Processor
104
Memory
106
Instructions
108
Look-up Table
150
Receivers
110
Blockage
Detection
130
112
114
116
118
120
122
124
132
134
136
138
140
142
144
152
154
156
158
160
162
164

FIG. 1

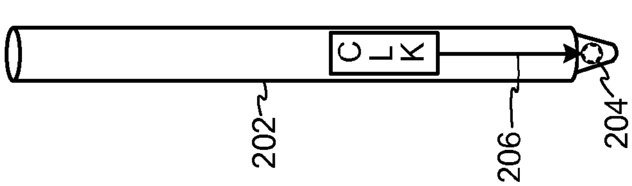

C
L
K
202
206
204

FIG. 2

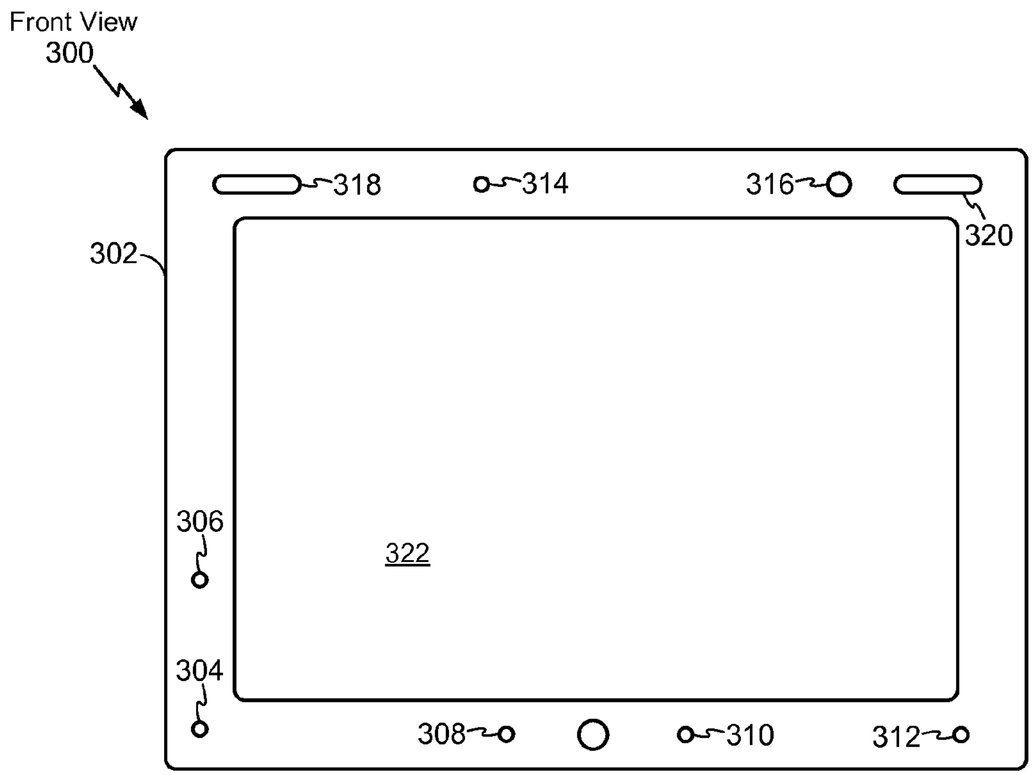

Front View
300
318
314
316
320
302
306
322
304
308
310
312

FIG. 3A

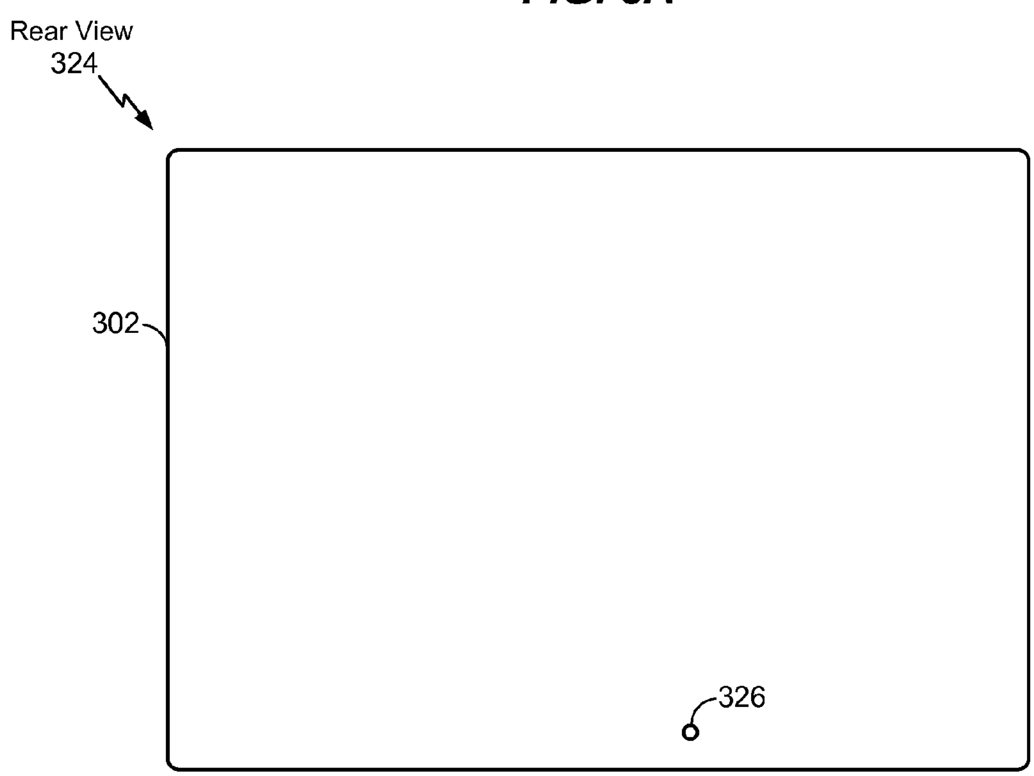

Rear View
324
302
326

FIG. 3B

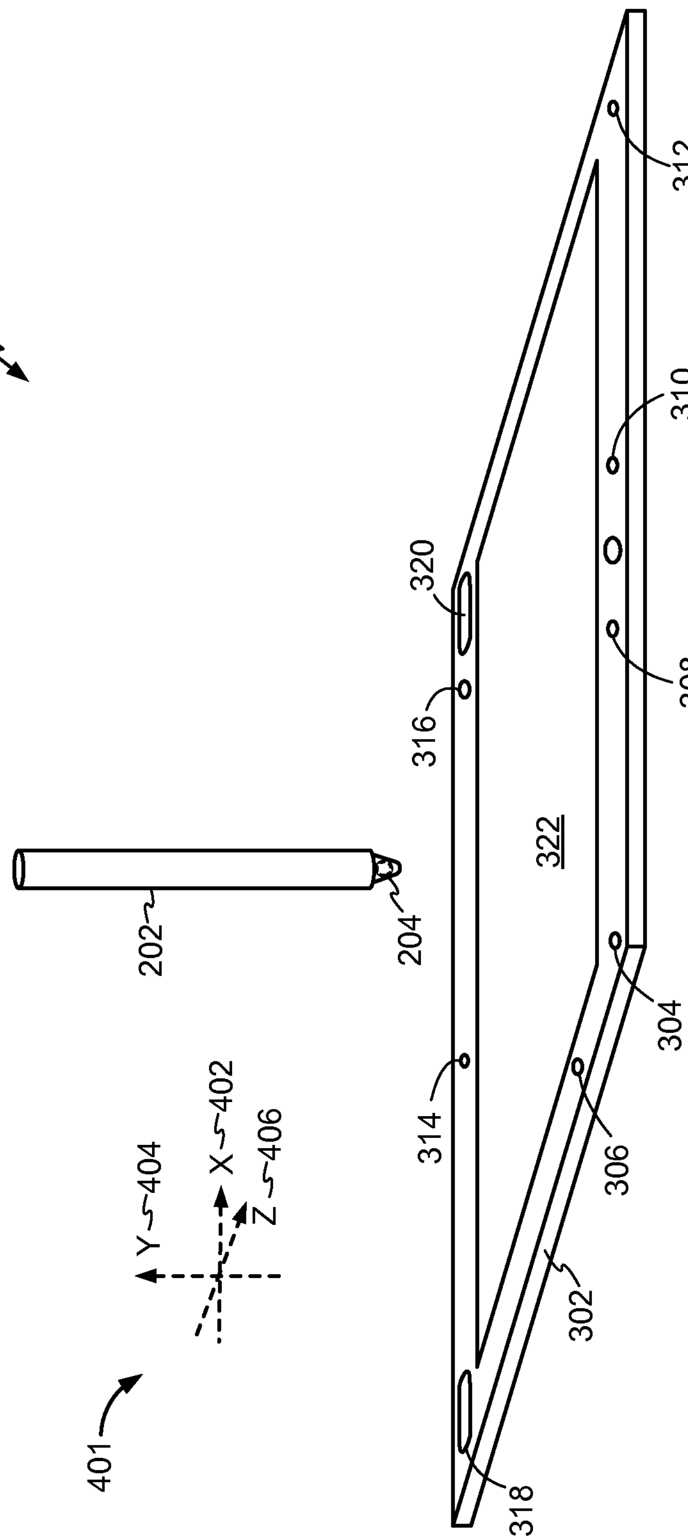

400
401
402
404
406
X
Y
Z
202
204
302
304
306
308
310
312
314
316
318
320
322

FIG. 4

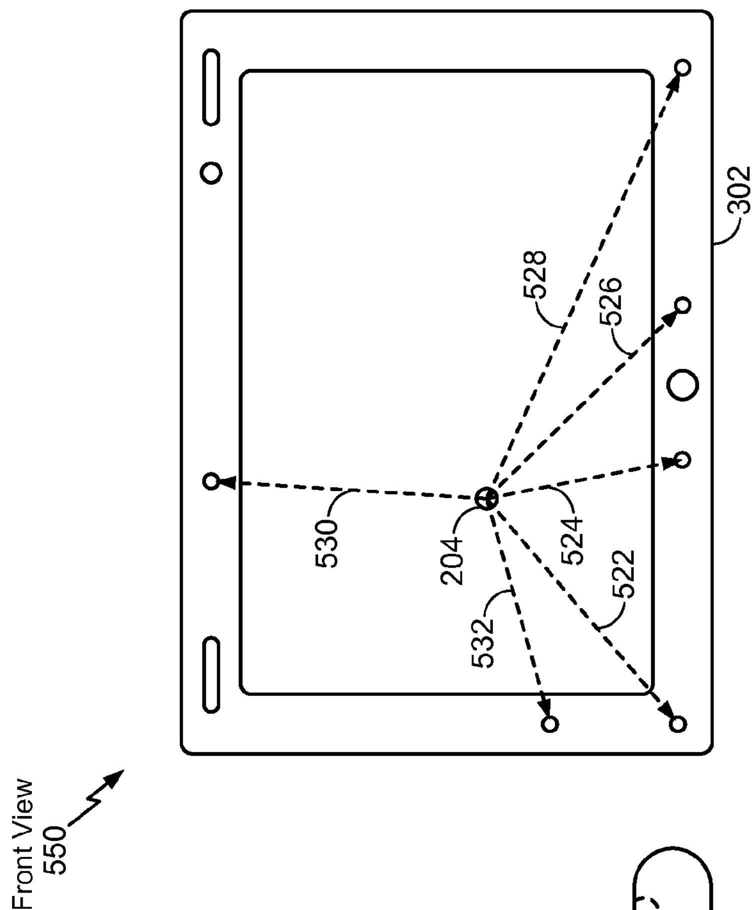

Front View
550
302
528
526
530
204
524
522
532

FIG. 5B

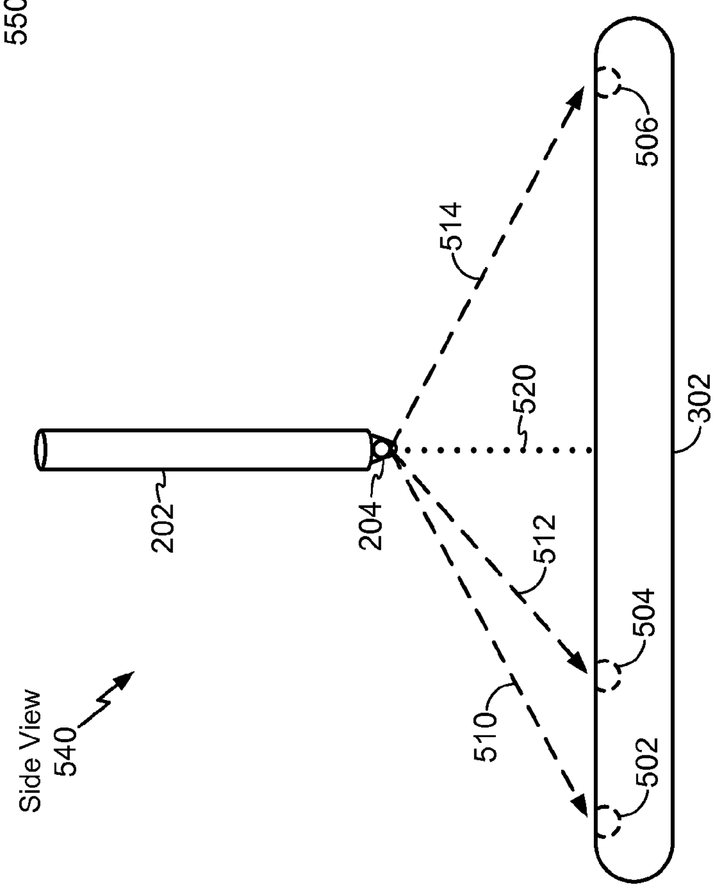

Side View
540
202
204
514
520
512
510
506
504
502
302

FIG. 5A

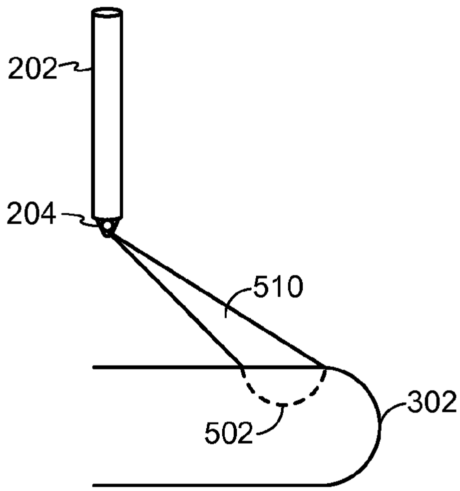


FIG. 6A

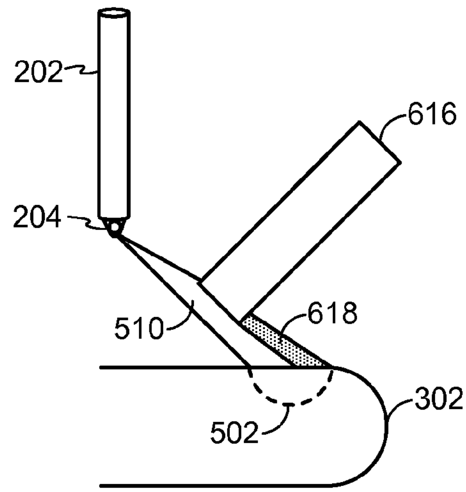


FIG. 6B

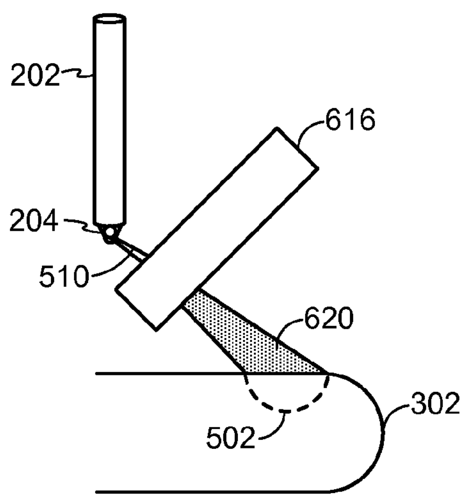


FIG. 6C

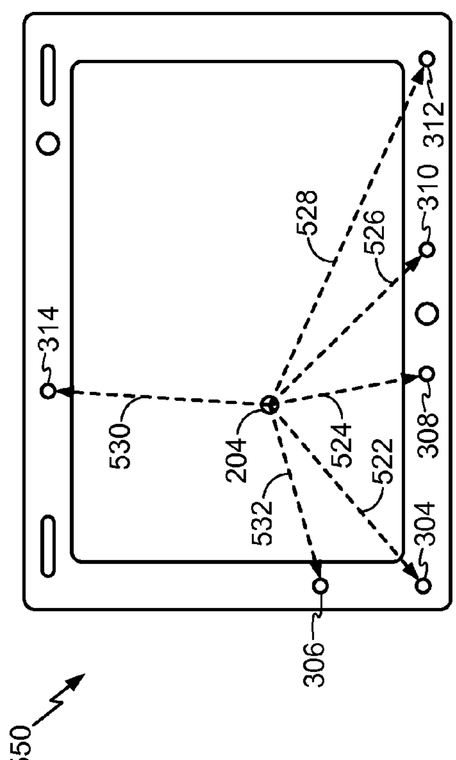


FIG. 7A

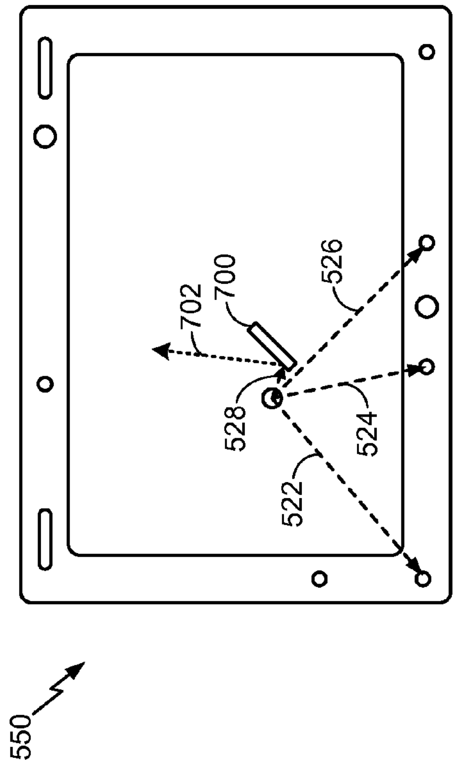


FIG. 7B

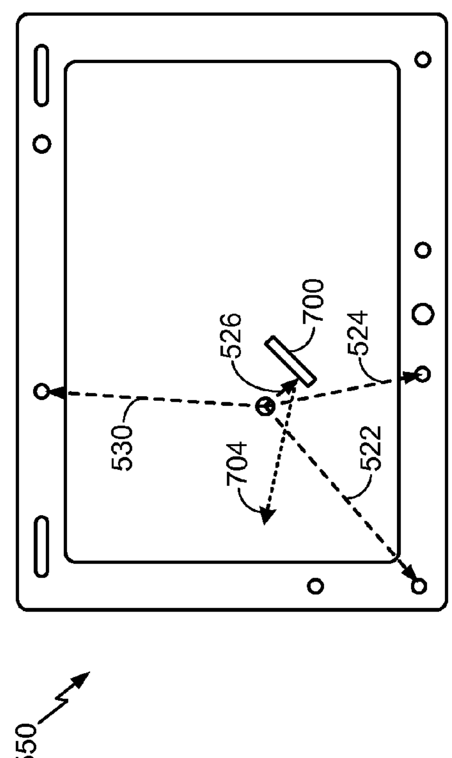


FIG. 7C

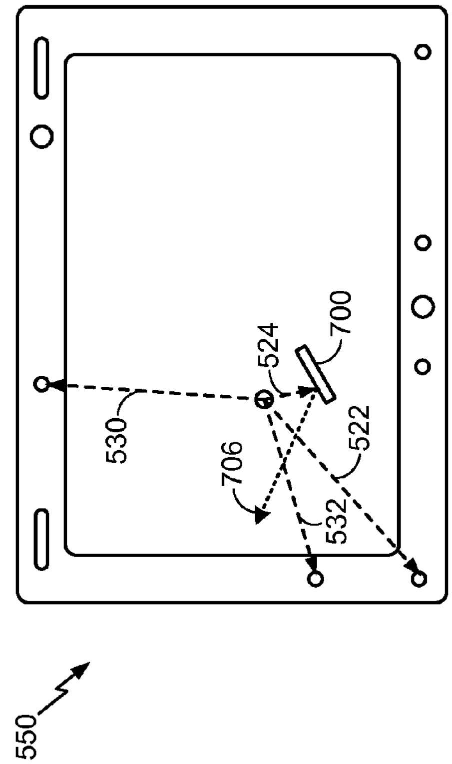


FIG. 7D

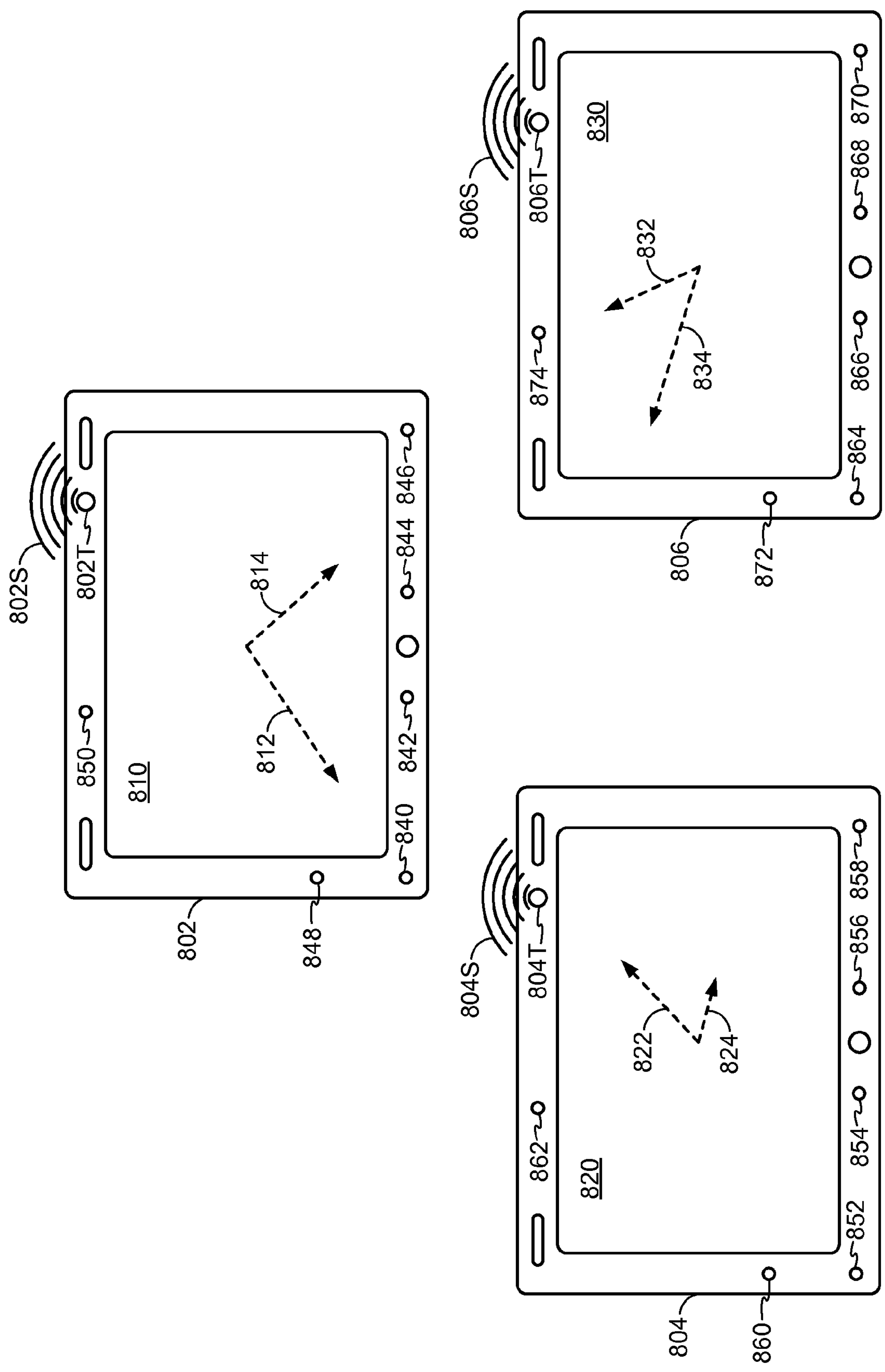

802S
802T
802
810
812
814
840
842
844
846
848
850
804S
804T
804
820
822
824
852
854
856
858
860
862
806S
806T
806
830
832
834
864
866
868
870
872
874

FIG. 8

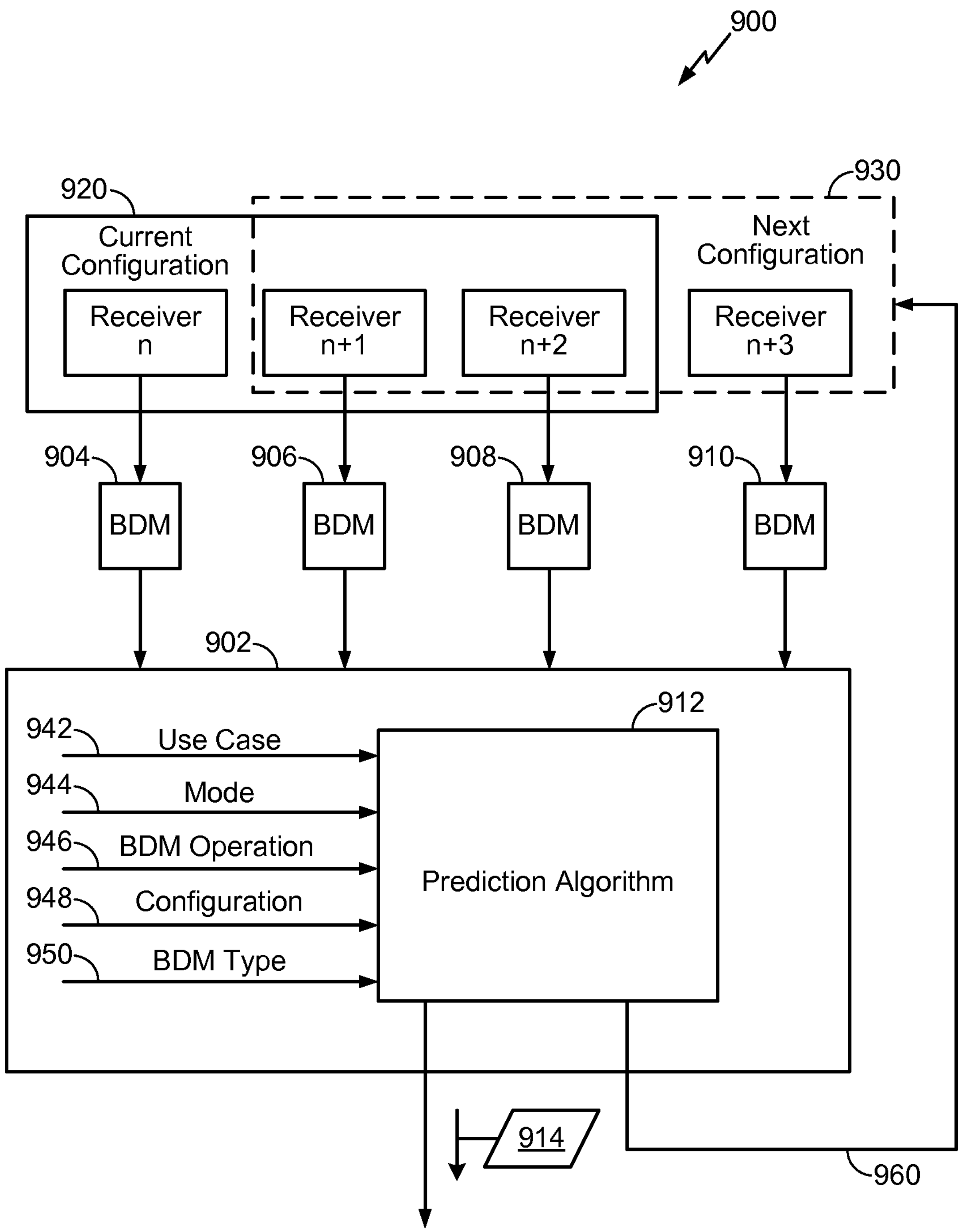

900
920
Current Configuration
930
Next Configuration
Receiver n
Receiver n+1
Receiver n+2
Receiver n+3
904
906
908
910
BDM
BDM
BDM
BDM
902
912
942
Use Case
944
Mode
946
BDM Operation
948
Configuration
950
BDM Type
Prediction Algorithm
914
960

FIG. 9

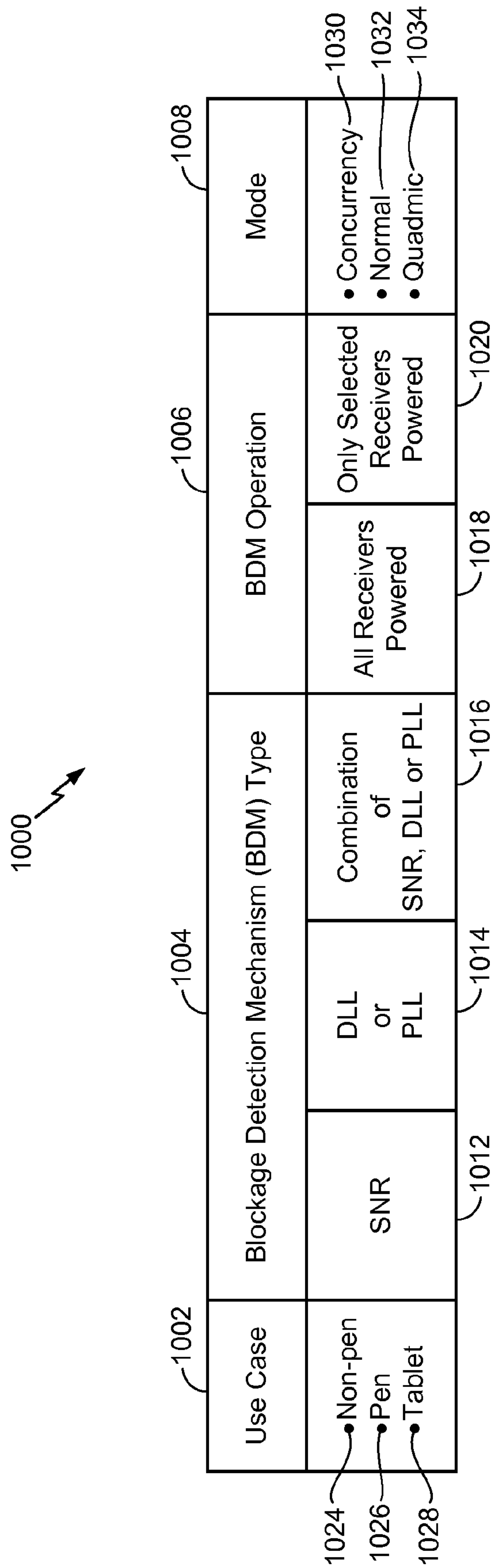

1000
Use Case
1002
Non-pen
Pen
Tablet
1024
1026
1028
Blockage Detection Mechanism (BDM) Type
1004
SNR
1012
DLL
or
PLL
1014
Combination
of
SNR, DLL or PLL
1016
BDM Operation
1006
All Receivers
Powered
1018
Only Selected
Receivers
Powered
1020
Mode
1008
Concurrency
Normal
Quadmic
1030
1032
1034

FIG. 10

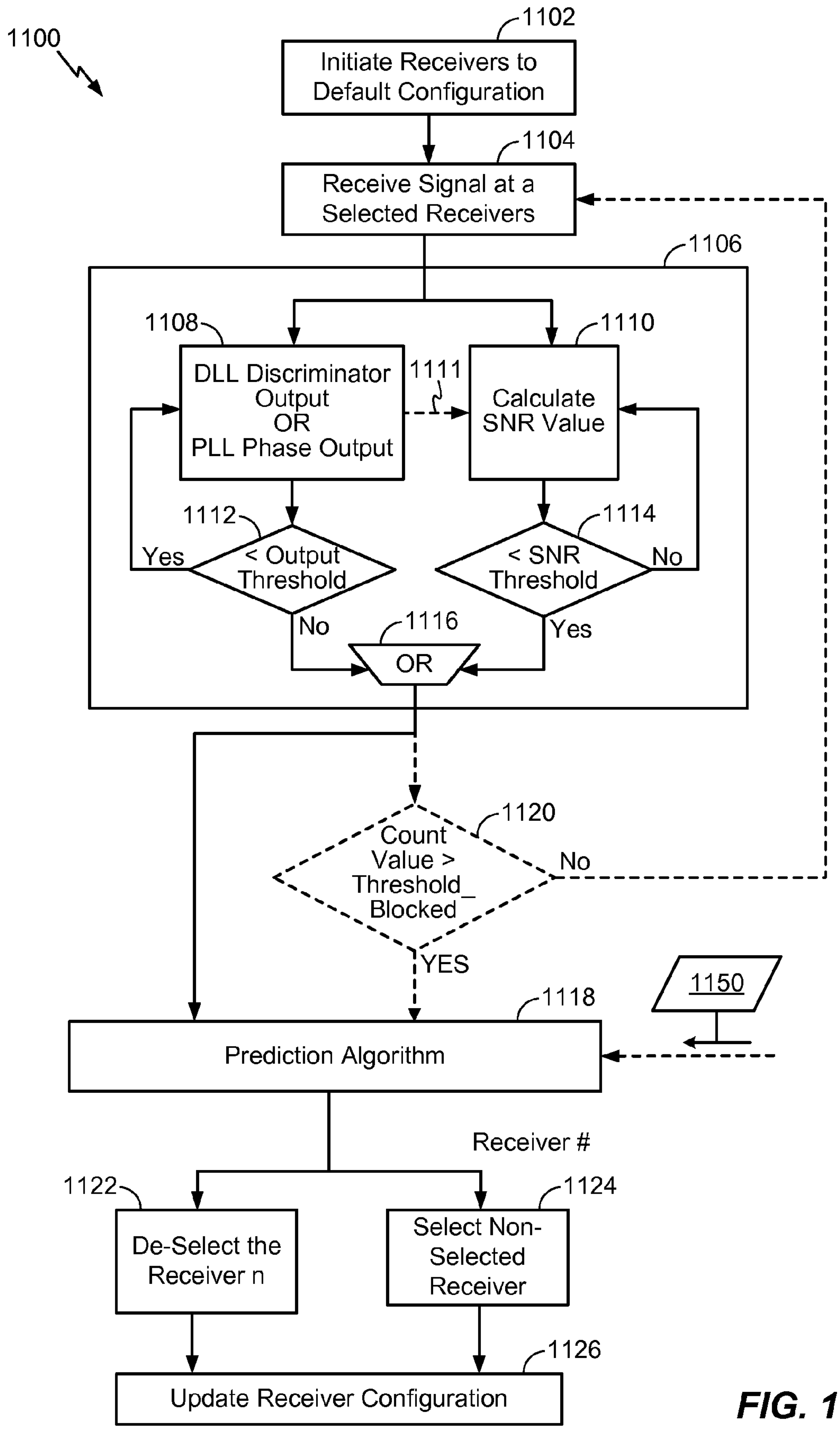

1100
1102
Initiate Receivers to Default Configuration
1104
Receive Signal at a Selected Receivers
1106
1108
DLL Discriminator Output OR PLL Phase Output
1111
1110
Calculate SNR Value
1112
< Output Threshold
Yes
No
1114
< SNR Threshold
No
Yes
1116
OR
1120
Count Value > Threshold_ Blocked
No
YES
1150
1118
Prediction Algorithm
Receiver #
1122
De-Select the Receiver n
1124
Select Non-Selected Receiver
1126
Update Receiver Configuration

FIG. 11

1202	1204	1206	1208	1210	1212	1214	1216	1218	1220	1222
Use	Mode	BDM Operation	RCVR5	RCVR4	RCVR3	RCVR2	RCVR1	Configuration	Predicted Receiver Option	BDM Type
Pen	Normal	Only Selected Mics On	0	0	1	1	1	1	4 or 5	SNR
			0	1	1	0	1	2	2 or 5	
			1	0	1	0	1	3	2 or 4	
			0	1	0	1	1	4	3 or 5	
			1	0	0	1	1	5	3 or 4	
			0	1	1	1	0	6	1 or 5	
			1	0	1	1	0	7	1 or 4	
			1	1	1	0	0	8	1 or 2	
			1	1	0	0	1	9	2 or 3	
			1	1	0	1	0	10	1 or 3	

FIG. 12

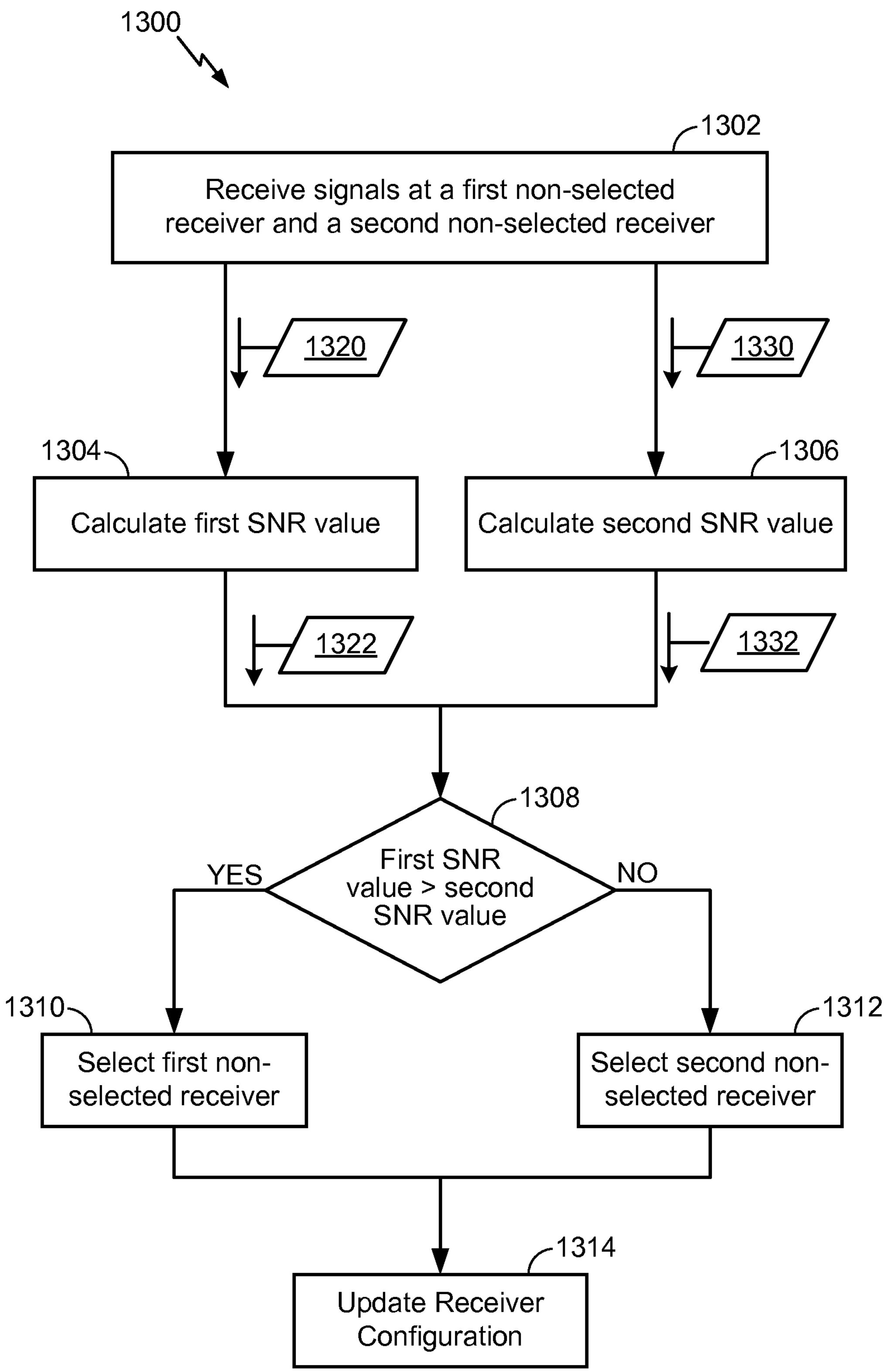

1300
1302
Receive signals at a first non-selected receiver and a second non-selected receiver
1320
1330
1304
Calculate first SNR value
1306
Calculate second SNR value
1322
1332
1308
First SNR value > second SNR value
YES
NO
1310
Select first non-selected receiver
1312
Select second non-selected receiver
1314
Update Receiver Configuration

FIG. 13

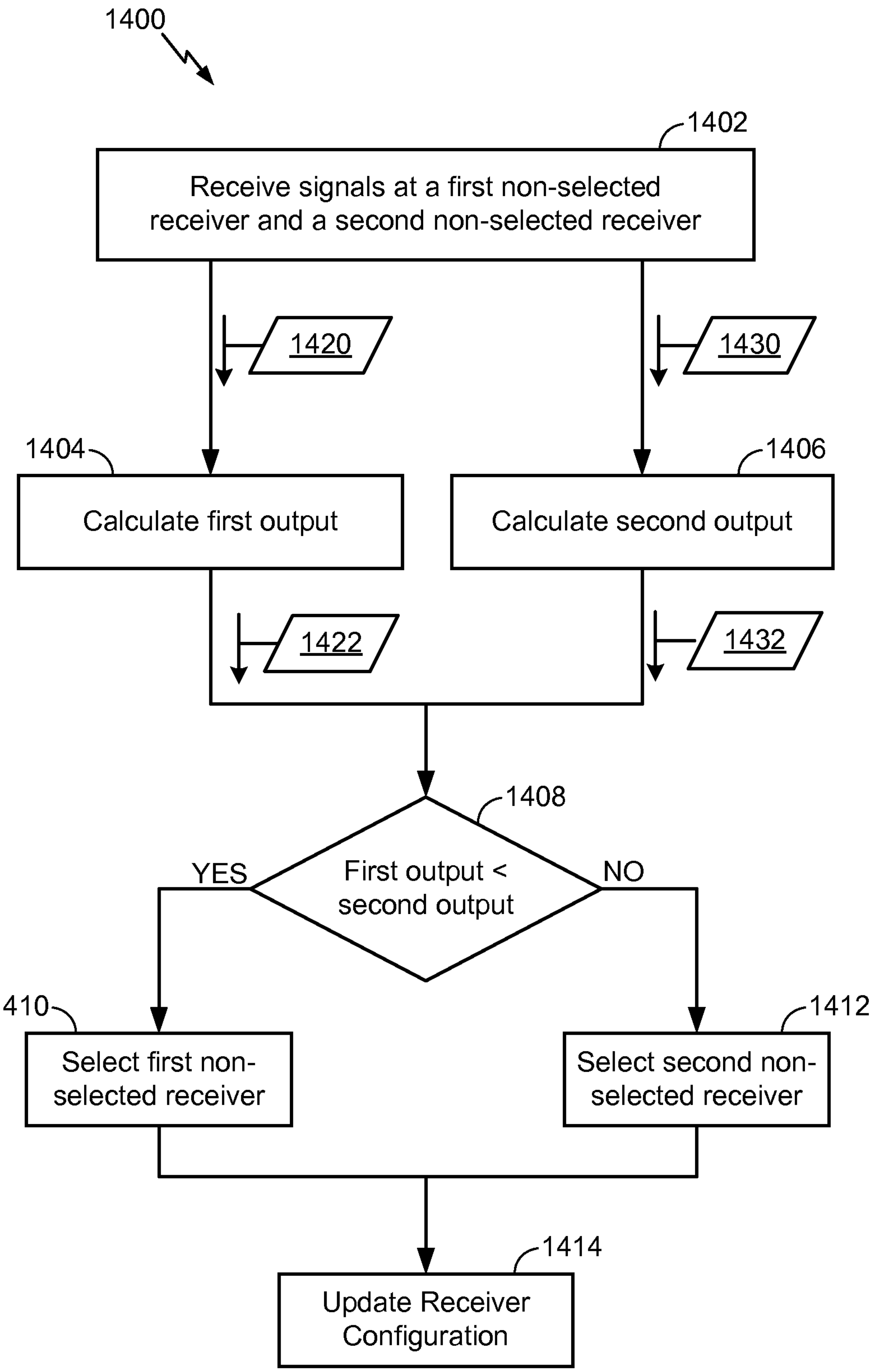

1400
1402
Receive signals at a first non-selected receiver and a second non-selected receiver
1420
1430
1404
Calculate first output
1406
Calculate second output
1422
1432
1408
First output < second output
YES
NO
1410
Select first non-selected receiver
1412
Select second non-selected receiver
1414
Update Receiver Configuration

FIG. 14

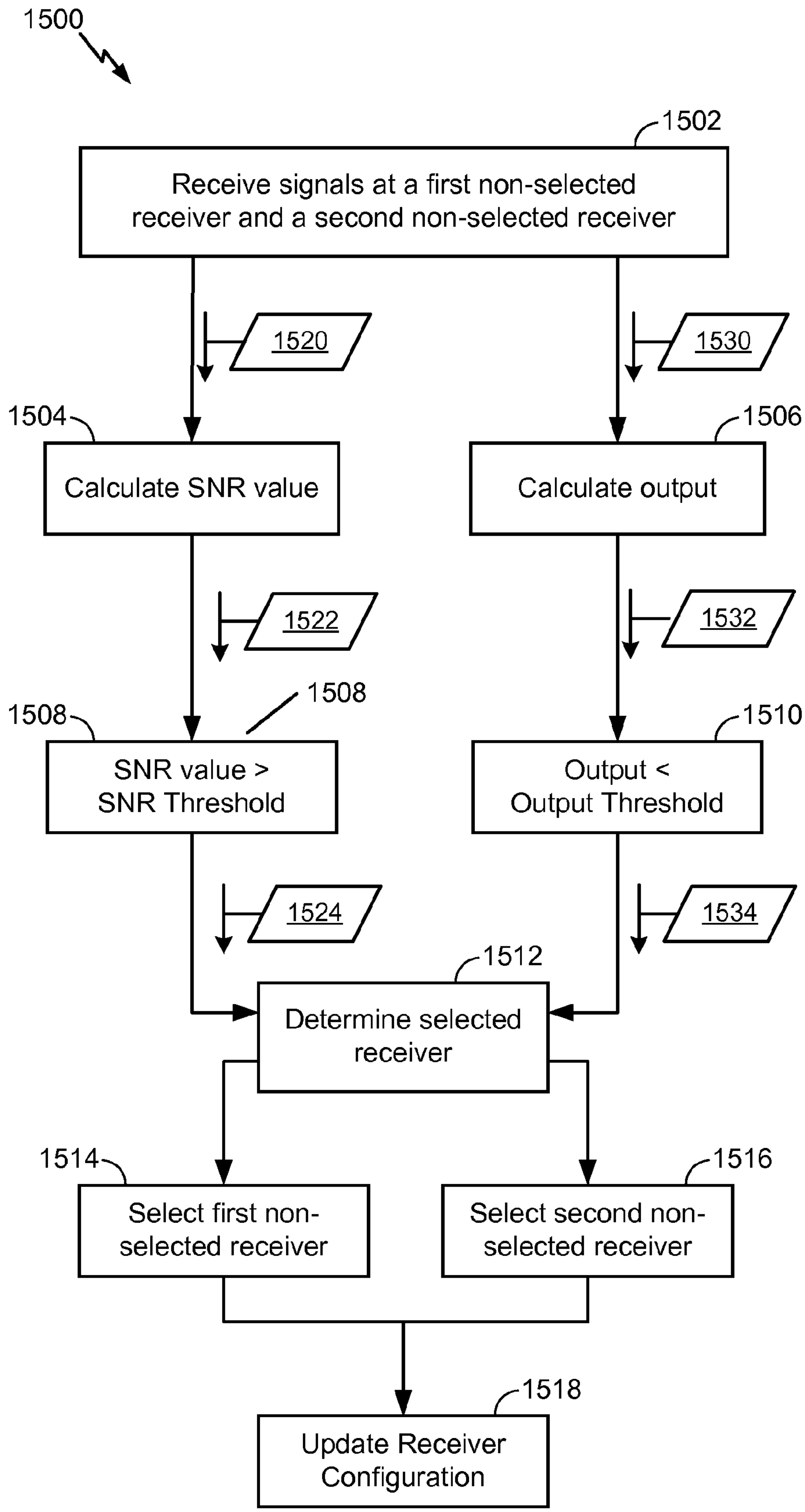

1500
1502
Receive signals at a first non-selected receiver and a second non-selected receiver
1520
1530
1504
Calculate SNR value
1506
Calculate output
1522
1532
1508
1508
SNR value > SNR Threshold
1510
Output < Output Threshold
1524
1534
1512
Determine selected receiver
1514
Select first non-selected receiver
1516
Select second non-selected receiver
1518
Update Receiver Configuration

FIG. 15

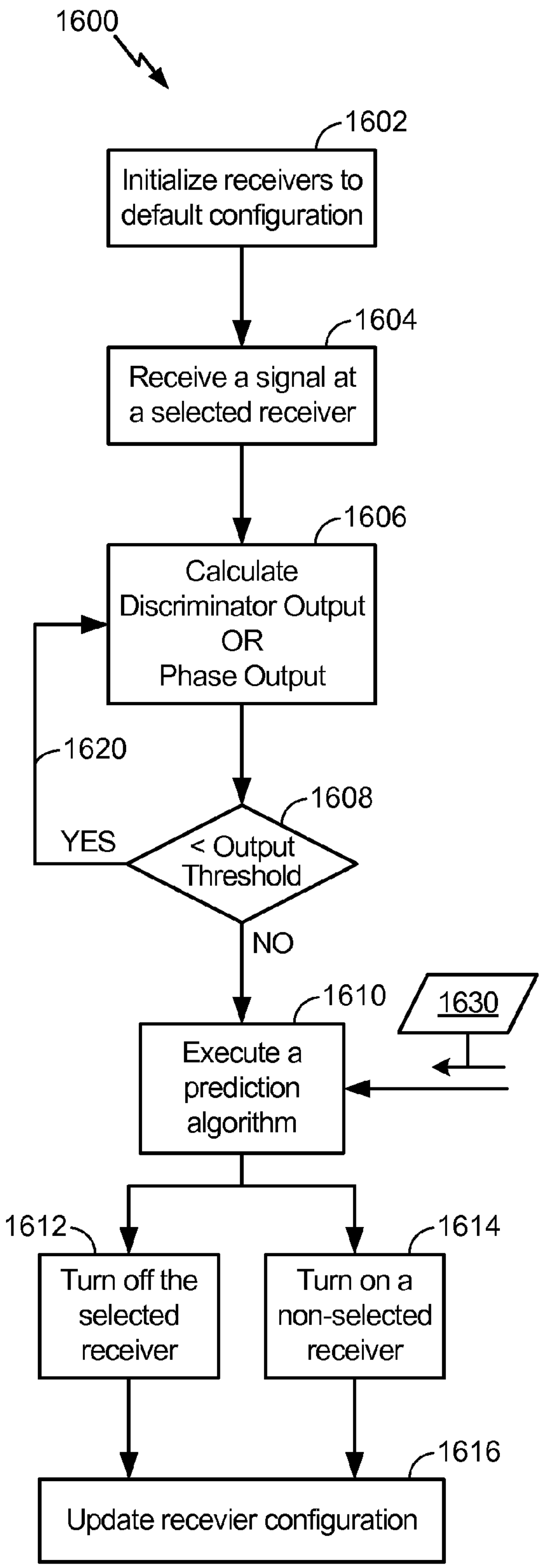


FIG. 16A

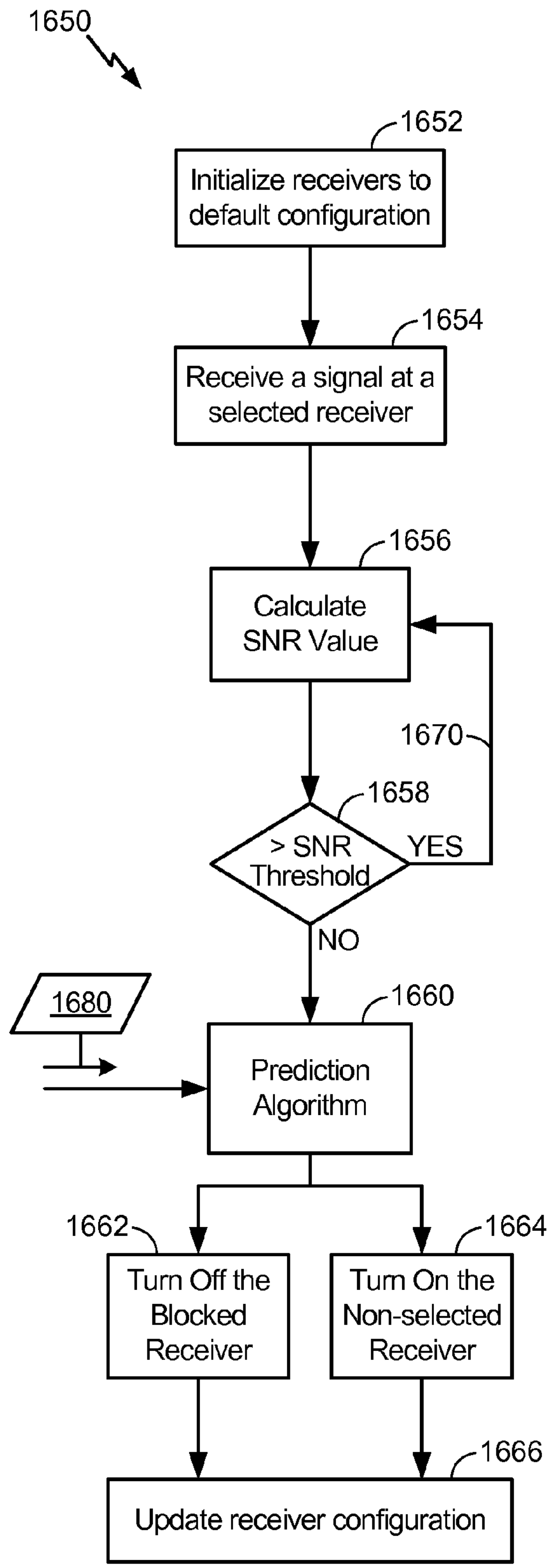


FIG. 16B

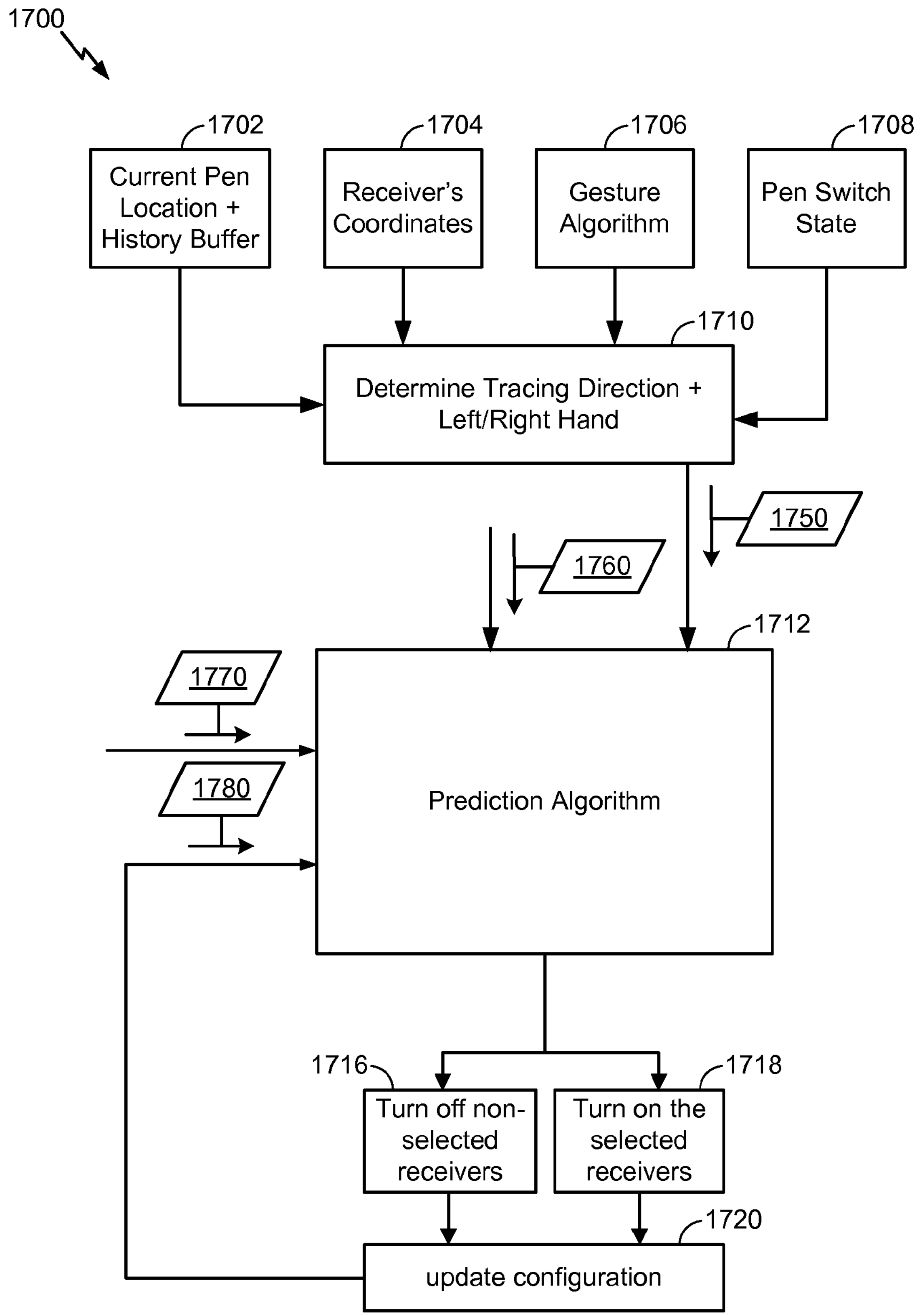

1700
1702
Current Pen Location + History Buffer
1704
Receiver's Coordinates
1706
Gesture Algorithm
1708
Pen Switch State
1710
Determine Tracing Direction + Left/Right Hand
1750
1760
1712
1770
1780
Prediction Algorithm
1716
Turn off non-selected receivers
1718
Turn on the selected receivers
1720
update configuration

FIG. 17

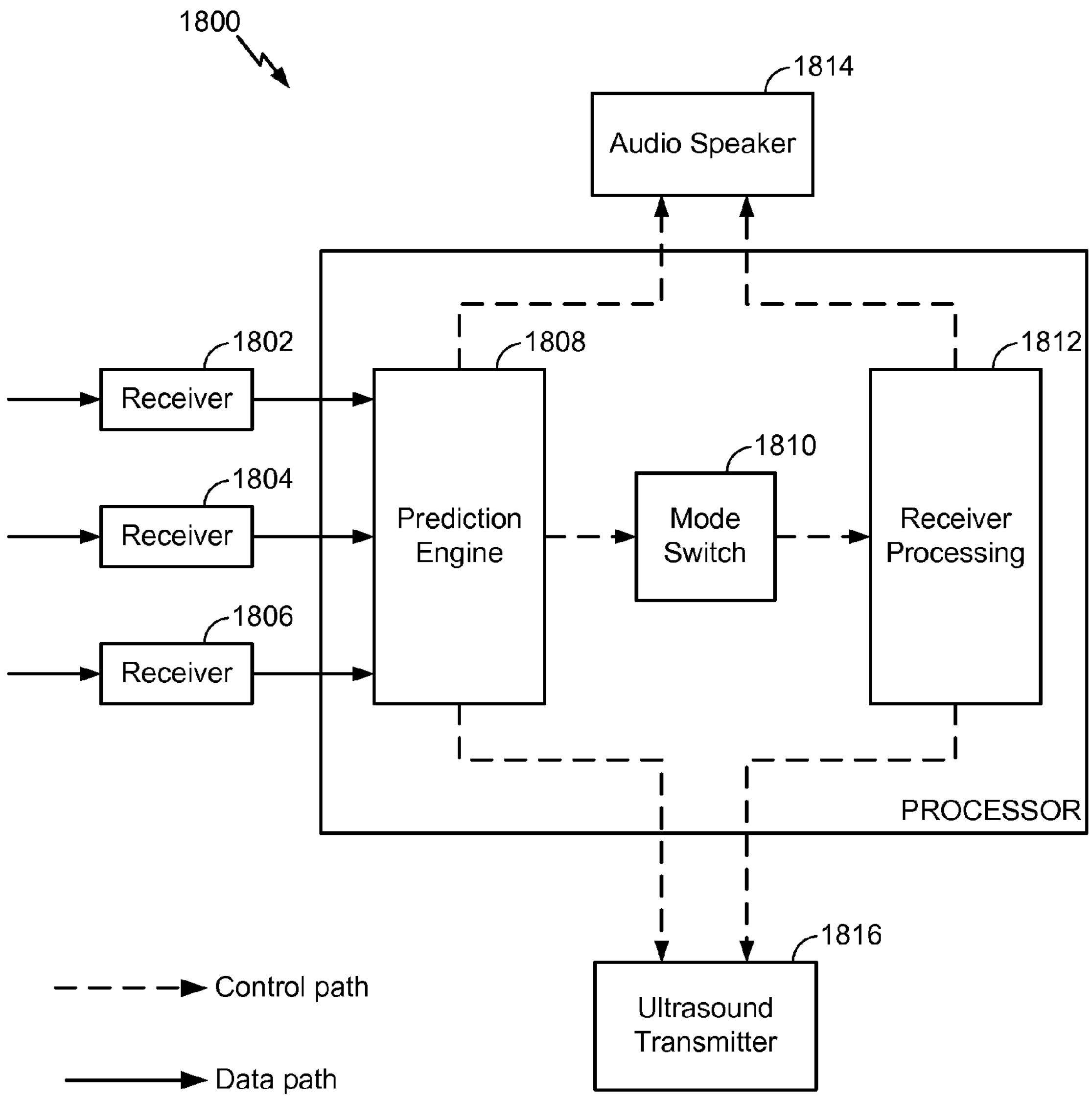

1800
1814
Audio Speaker
1802
Receiver
1804
Receiver
1806
Receiver
1808
Prediction Engine
1810
Mode Switch
1812
Receiver Processing
PROCESSOR
1816
Ultrasound Transmitter
Control path
Data path

FIG. 18

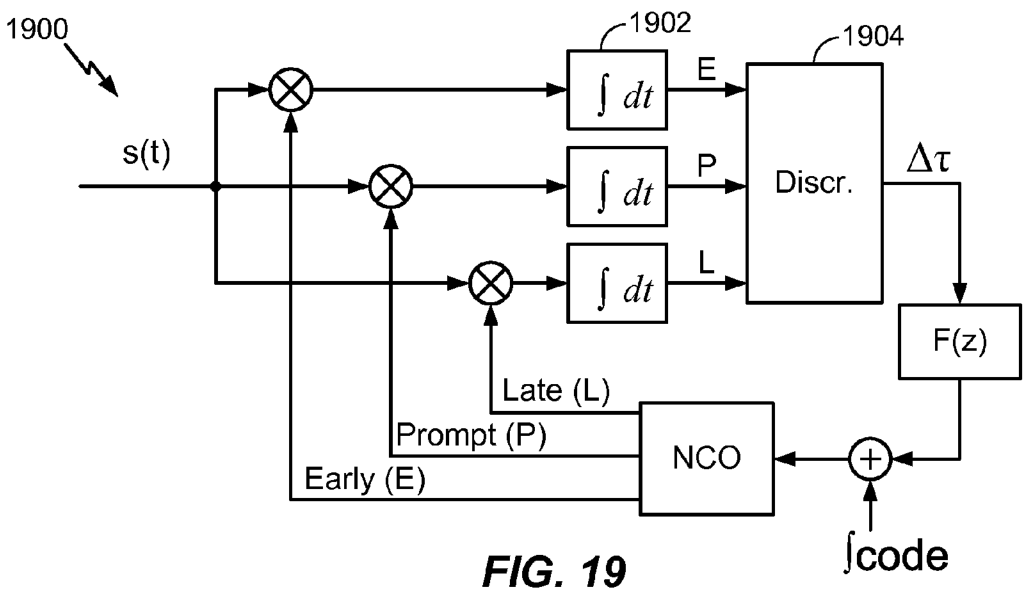


FIG. 19

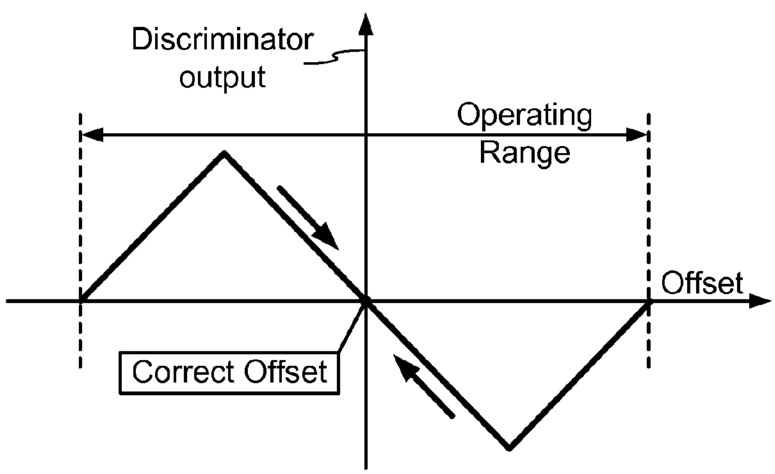


FIG. 20

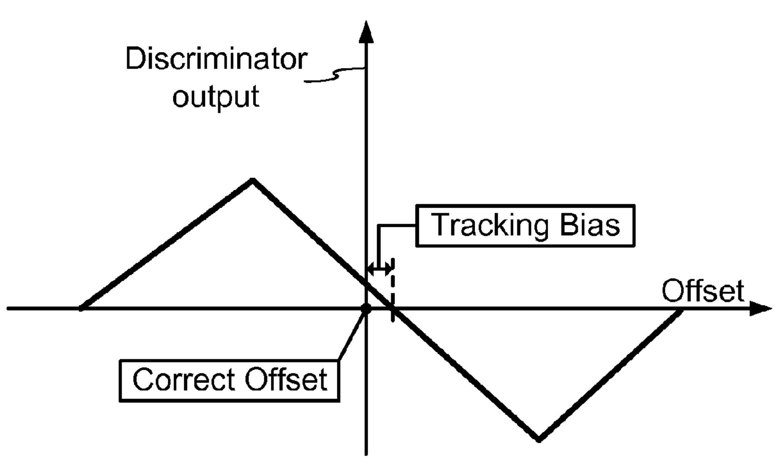


FIG. 21

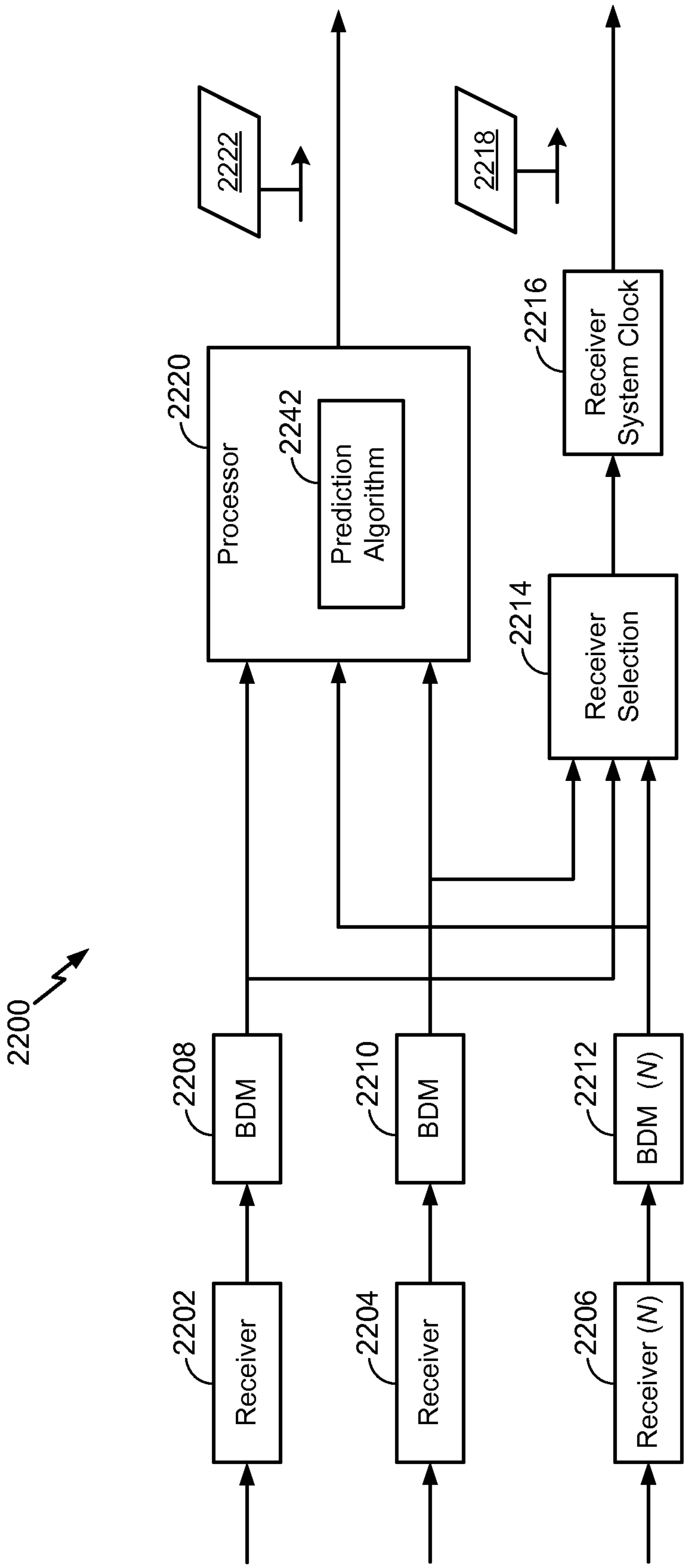
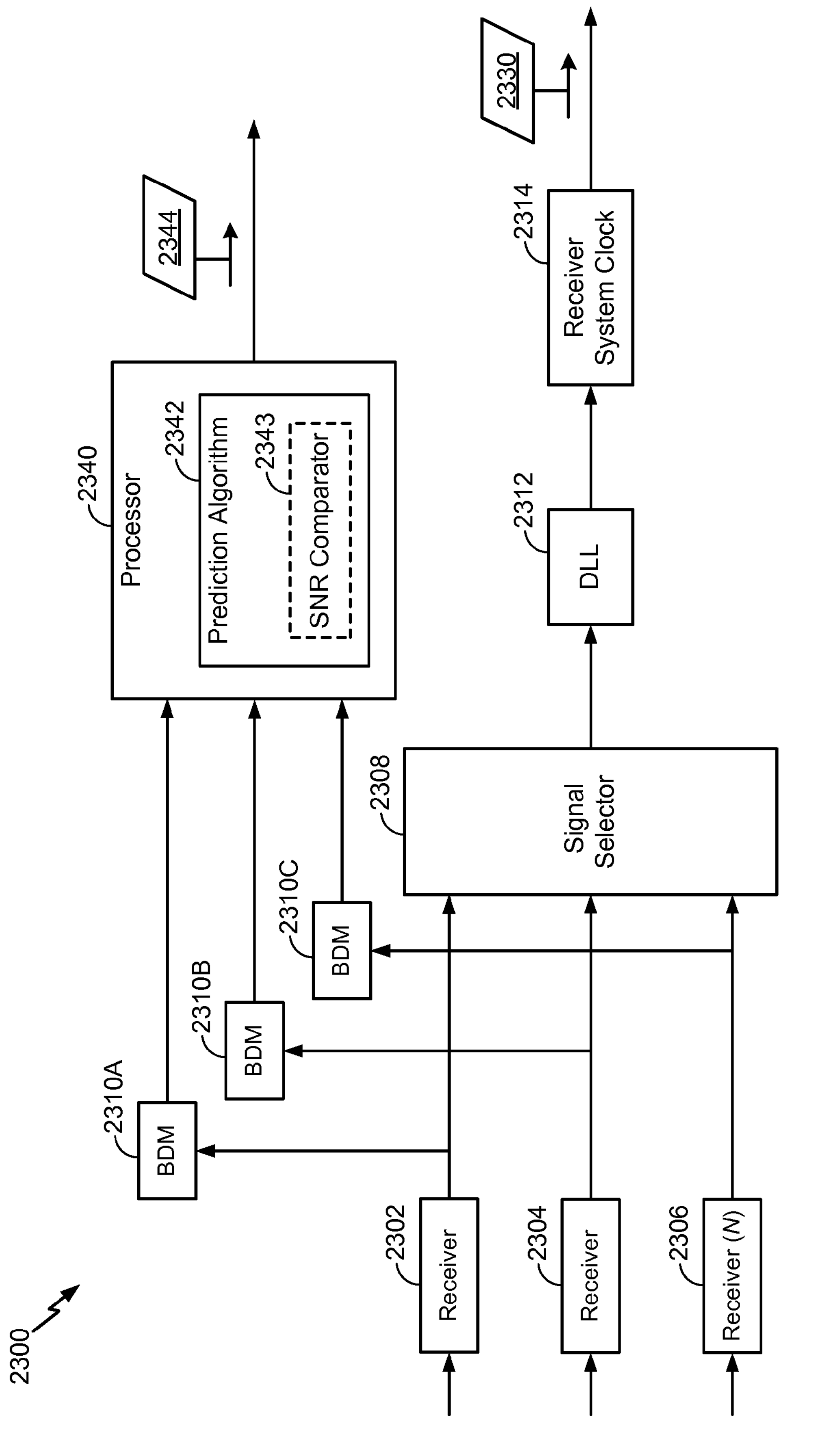

2200
2202
Receiver
2204
Receiver
2206
Receiver (N)
2208
BDM
2210
BDM
2212
BDM (N)
2214
Receiver Selection
2216
Receiver System Clock
2218
2220
Processor
2242
Prediction Algorithm
2222

FIG. 22



2300
2302
Receiver
2304
Receiver
2306
Receiver (N)
2310A
BDM
2310B
BDM
2310C
BDM
2308
Signal Selector
2312
DLL
2314
Receiver System Clock
2330
2340
Processor
2342
Prediction Algorithm
2343
SNR Comparator
2344

FIG. 23

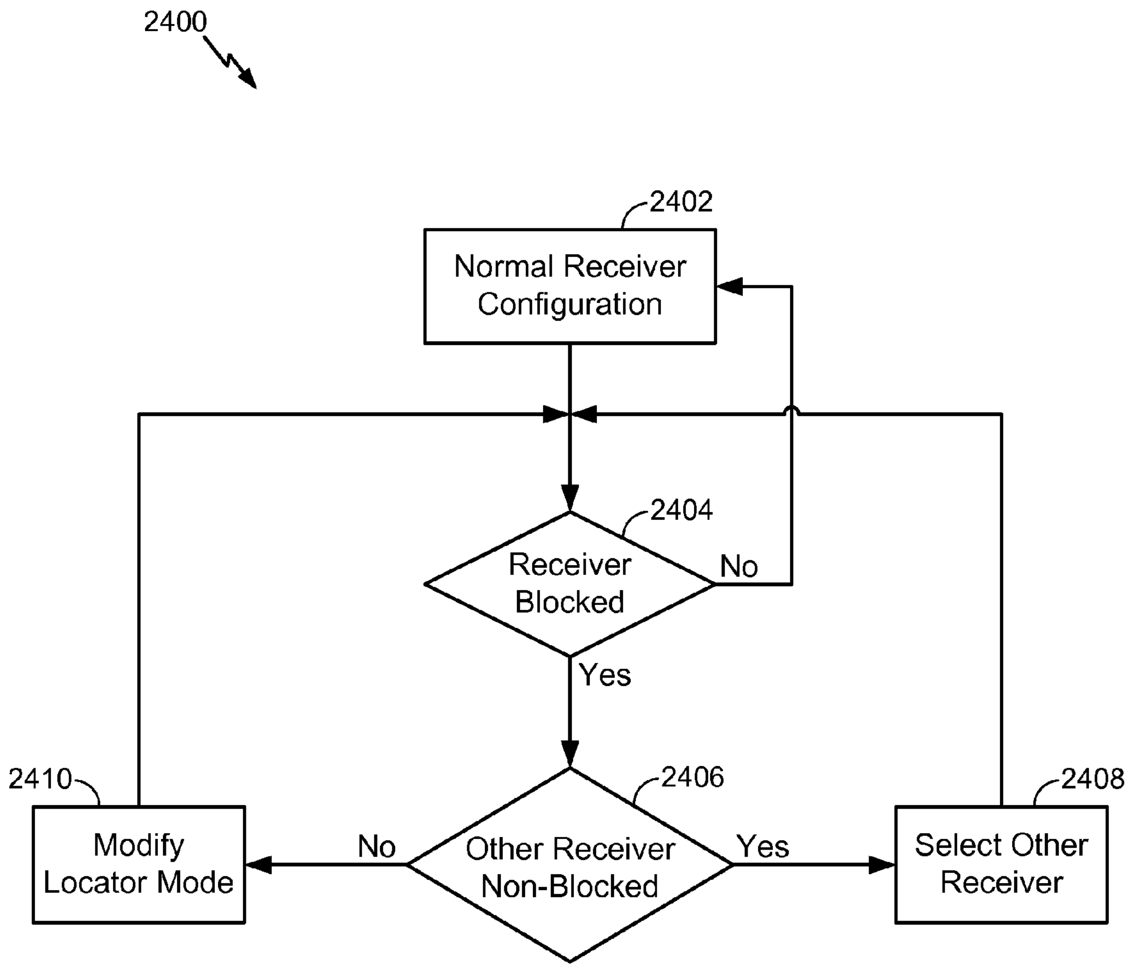

2400
2402
Normal Receiver Configuration
2404
Receiver Blocked
No
Yes
2406
Other Receiver Non-Blocked
No
Yes
2410
Modify Locator Mode
2408
Select Other Receiver

FIG. 24

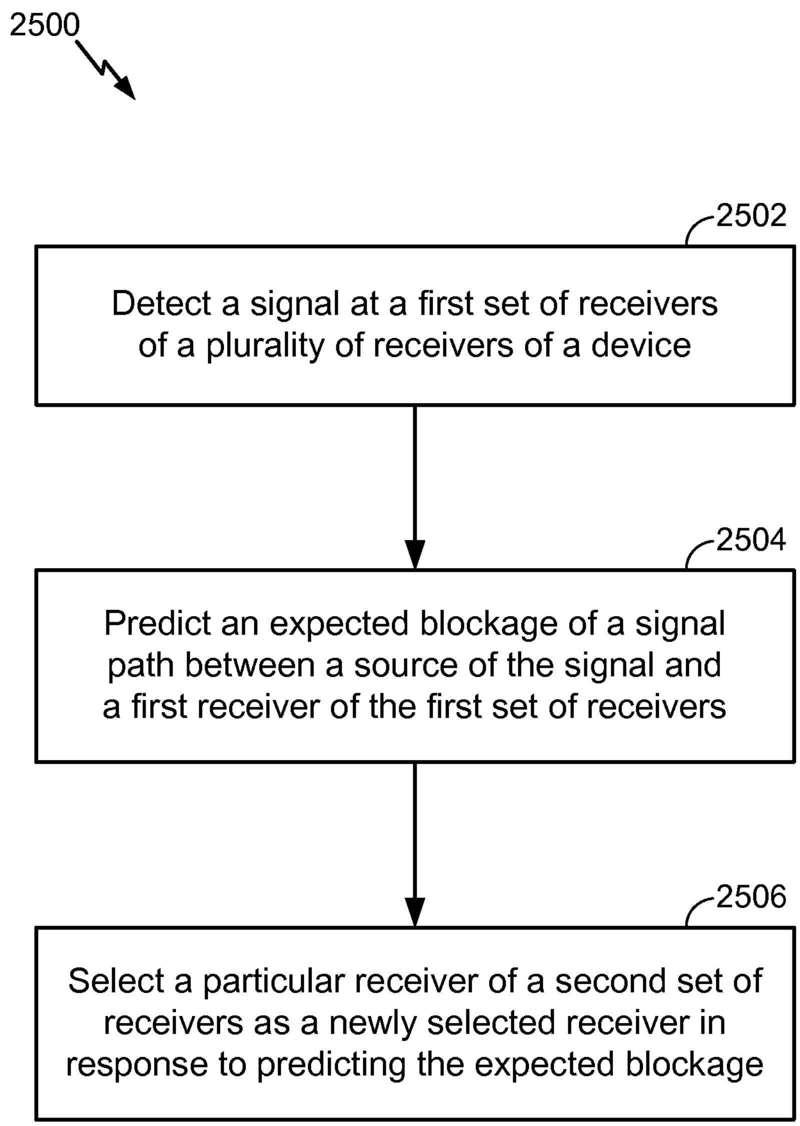
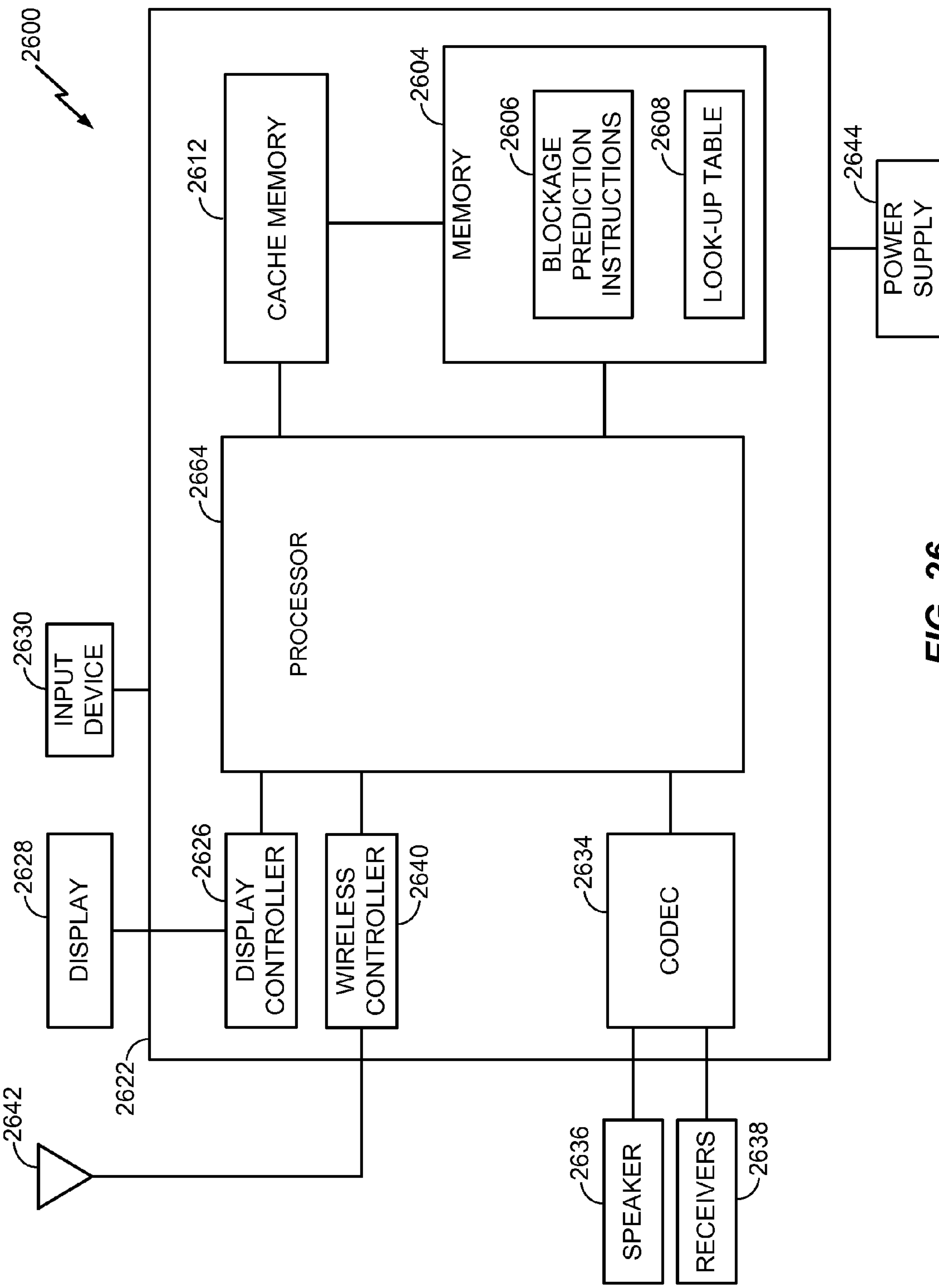

2500
2502
Detect a signal at a first set of receivers of a plurality of receivers of a device
2504
Predict an expected blockage of a signal path between a source of the signal and a first receiver of the first set of receivers
2506
Select a particular receiver of a second set of receivers as a newly selected receiver in response to predicting the expected blockage

FIG. 25



2600
2604
MEMORY
2606
BLOCKAGE PREDICTION INSTRUCTIONS
2608
LOOK-UP TABLE
2612
CACHE MEMORY
2644
POWER SUPPLY
2664
PROCESSOR
2630
INPUT DEVICE
2628
DISPLAY
2626
DISPLAY CONTROLLER
WIRELESS CONTROLLER
2640
2634
CODEC
2622
2642
2636
SPEAKER
RECEIVERS
2638

FIG. 26

SYSTEMS AND METHODS FOR PREDICTING AN EXPECTED BLOCKAGE OF A SIGNAL PATH OF AN ULTRASOUND SIGNAL

CLAIM OF PRIORITY

This application claims priority from U.S. provisional application No. 61/576,893 filed on Dec. 16, 2011 and entitled "Systems and Methods for Predicting an Expected Blockage of a Signal Path of an Ultrasound Signal," the contents of which are expressly incorporate herein by reference.

FIELD OF THE DISCLOSURE

The present disclosure is generally related to ultrasound transmitter and receiving systems.

BACKGROUND

Time difference of arrival (TDOA) can be used to determine the location of an object relative to a tablet or other computing device. For example, a pen (e.g., a stylus) may include a transmitter configured to transmit an ultrasound signal. The ultrasound signal may be detected by receivers (e.g., microphones) on the tablet. Timing differences between signals received at different receivers can be used to detect position and movement of the pen (based on how long it took the ultrasound signal to travel from the pen to the microphones).

Ultrasound signal energy decays faster than audio band signal energy and may require line of sight (LOS) between transmitters and receivers. Systems that use an ultrasound transmitter and at least one receiver may not properly determine the location of the pen when a LOS signal path between the transmitter and the at least one receiver is blocked. For example, when a user is using the pen, his or her hand or another object can block the signal path between the pen and a receiver. One approach to avoid the blocking problem is to have many redundant receivers operating at the same time. This approach uses more power due to having all receivers (e.g., microphones) powered at the same time and consumes more bandwidth between a hardware codec and a system processor.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram of an illustrative embodiment of a system for predicting an expected blockage of a signal path of an ultrasound signal;

FIG. **2** is diagram of an embodiment of a ultrasonic stylus pen;

FIGS. **3**A and **3**B illustrate an embodiment of a system for predicting an expected blockage of a signal path of an ultrasound signal;

FIG. **4** illustrates another embodiment of a system for predicting an expected blockage of a signal path of an ultrasound signal;

FIGS. **5**A and **5**B illustrate another embodiment of a system for predicting an expected blockage of a signal path of an ultrasound signal;

FIGS. **6**A, **6**B, and **6**C illustrate another embodiment of a system for use in detecting blocking of an ultrasound signal;

FIGS. **7**A, **7**B, **7**C, and **7**D illustrate another embodiment of a system for predicting an expected blockage of a signal path of an ultrasound signal;

FIG. **8** illustrates another embodiment of a system for predicting an expected blockage of a signal path of an ultrasound signal;

FIG. **9** is a block diagram of a system to determine a set of selected receivers and a set of de-selected receivers;

FIG. **10** is a table illustrating various prediction algorithm input values;

FIG. **11** is a particular embodiment of a method for updating a receiver configuration using a prediction algorithm;

FIG. **12** is a portion of a lookup table for use with a prediction algorithm;

FIG. **13** is a flowchart of a method of selecting a non-selected receiver in response to predicting an expected blockage of a selected receiver;

FIG. **14** is a flowchart of another method of selecting a non-selected receiver in response to predicting an expected blockage of a selected receiver;

FIG. **15** is a flowchart of another method of selecting a non-selected receiver in response to predicting an expected blockage of a selected receiver;

FIG. **16**A is a flowchart of a method of providing power to selected receivers based on an output of a blockage detection mechanism (BDM) including a delay locked loop (DLL) or a phase locked loop (PLL);

FIG. **16**B is a flowchart of a method of providing power to selected receivers based on an output of a blockage detection mechanism (BDM) configured to generate a signal to noise ratio (SNR) value;

FIG. **17** is a flowchart of a method of predicting an expected blockage of a selected receiver;

FIG. **18** is illustrates an embodiment of a system to predict an expected blockage of a selected receiver;

FIG. **19** is an illustrative example of a circuit for implementing a delay locked loop (DLL) for use in predicting an expected blockage of a signal path of a signal;

FIG. **20** illustrates an example of an output of the DLL of FIG. **19**;

FIG. **21** illustrates another example of an output of the DLL of FIG. **19**;

FIG. **22** illustrates another embodiment of a system for predicting an expected blockage of a signal path of an ultrasound signal;

FIG. **23** illustrates another embodiment of a system for predicting an expected blockage of a signal path of an ultrasound signal

FIG. **24** is a flowchart of another embodiment of a method for predicting an expected blockage of a signal path of a signal;

FIG. **25** is a flowchart of a method of selecting a non-selected receiver; and

FIG. **26** is a block diagram of an illustrative embodiment of a computer system operable to support the various methods, systems, devices, and computer readable media described with respect to FIGS. **1**-**25**.

DETAILED DESCRIPTION

A system, method, and apparatus to locate an object are disclosed. The system and apparatus include a plurality of receivers configured to receive a signal from a transmitter. The system and apparatus include logic (e.g., circuitry) to determine a location of the object based on signals received at selected receivers (e.g., a first set of receivers) of the plurality of receivers. The system and apparatus are operable to predict an expected blockage of a signal path between the object and at least one of the selected receivers. The system and apparatus are operable to select a receiver from among the non-blocked receivers (e.g., a second set of receivers) in response to predicting the expected blockage. In a particular embodiment, a method of selecting a non-selected receiver of a device is disclosed. The method includes detecting a signal at selected receivers of the device. The device includes at least one non-selected receiver. The method includes predicting, based on the signal, an expected blockage of a signal path between a source of the signal and a first selected receiver. The method further includes selecting a second receiver from among the at least one non-selected receiver in response to predicting the expected blockage.

In another embodiment, a system is configured to select a non-selected receiver of a device. The system includes a plurality of receivers, a processor, and a memory. The plurality of receivers includes selected receivers (e.g., a first set of receivers) and at least one non-selected receiver (e.g., a second set of receivers). The memory may store instructions executable by the processor. The instructions may be executable by the processor to detect a signal at each of the selected receivers. The instructions may be further executable by the processor to predict, based on the signal, an expected blockage of a signal path between a source of the signal and a first selected receiver. The instructions may be further executable by the processor to select at least one of the non-selected receivers in response to predicting the expected blockage of the signal path.

Referring to FIG. **1**, an illustrative embodiment of a device **100** is shown. The device **100** includes a processor **102**, a memory **104**, and a plurality of receivers **110**. The device **100** may be a tablet, a personal computing device, a laptop computing device, a wireless communication device, a personal digital assistant (PDA), another computing device, or any combination thereof. In an embodiment, the plurality of receivers **110** are arranged about one or more surfaces of the device **100**, as described further with reference to FIGS. **3**A and **3**B. In an embodiment, the plurality of receivers **110** comprises a plurality of microphones. At least one microphone of the plurality of microphones may be configured to detect an ultrasound signal (e.g., an acoustic signal having a frequency in excess of twenty (20) kiloHertz (kHz)). In a particular embodiment, one or more of the microphones may be configured to detect the ultrasound signal and an audio signal (e.g., an acoustic signal having a frequency between twenty (20) Hertz (Hz) and twenty (20) kHz). In a particular embodiment, the ultrasound signal may correspond to an acoustic signal that is outside of a human auditory range (i.e., signals having a frequency in excess of twenty (20) kHz) and the audio signal may correspond to an acoustic signal that is within the human auditory range (e.g., signals having a frequency between twenty (20) Hertz (Hz) and twenty (20) kHz).

As shown in FIG. **1**, the processor **102**, or another component of the device **100**, may generate or otherwise communicate a clock signal **150** to the plurality of receivers **110**. The plurality of receivers **110** may synchronize to the clock signal **150**. The clock signal **150** may be synchronized to a clock external to the device **100**. By synchronizing the clock signal **150** with the clock external to the device **100**, the processor **102** may determine a location of a device transmitting a signal using time difference of arrival.

The plurality of receivers **110** includes selected receivers (e.g., a first set of receivers) and non-selected receivers (e.g., a second set of receivers). The selected receivers correspond to a first set of receivers of the plurality of receivers **110** that are to be used by the processor **102** when determining the location of the device transmitting the signal. The non-selected receivers may correspond to a second set of receivers of the plurality of receivers **110** that are not to be used by the processor **102** when determining the location of the device transmitting the signal. In an embodiment, each of the plurality of receivers **110** may be activated (e.g., receiving power) and may receive the signal from the transmitter. In this embodiment, the signals received at the selected receivers may be used by the processor **102** to determine the location of the device transmitting the signal and the signals received at the non-selected receivers may not be used by the processor **102**. In an alternative embodiment, the selected receivers may be activated (e.g., receiving power) and may receive the signal from the device. In this embodiment, the non-selected receivers may be deactivated (e.g., not receiving power) and may not receive the signal from the device.

As shown in FIG. **1**, the memory **104** includes instructions **106**. The instructions **106** may include instructions executable by the processor **102** to detect a signal at the selected receivers (e.g., the first set of receivers) of the plurality of receivers **110**. The instructions **106** may further include instructions executable by the processor **102** to predict, based on the signal, an expected blockage of a signal path between a source of the signal and a first selected receiver. The instructions **106** may further include instructions executable by the processor **102** to select a second selected receiver from among the at least one non-selected receiver (e.g., the second set of receivers) of the plurality of receivers **110** in response to predicting the expected blockage of the signal path between the source of the signal and the first selected receiver.

The instructions **106** may include instructions to de-select the first selected receiver in response to selecting the at least one non-selected receiver. De-selecting the first selected receiver may include designating the first selected receiver as a non-selected receiver (e.g., as included in the second set of receivers) due to the predicted blockage of the signal path between the source of the signal and the first selected receiver. When the first selected receiver is de-selected, the first selected receiver becomes a first non-selected receiver and is not used by the processor **102** to determine the location of the device transmitting the signal. In a particular embodiment, when the selected receivers are activated (e.g., receiving power) and the non-selected receivers are deactivated (e.g., not receiving power), the instructions to de-select the first selected receiver may be executable by the processor **102** to cause the device **100** to deactivate (i.e., no longer provide power to) the de-selected receiver (i.e., the first non-selected receiver).

As shown in FIG. **1**, each of the plurality of receivers **110** is coupled to a blockage detection mechanism (BDM) **130**. For example, in FIG. **1** a first receiver **112** is coupled to a first BDM **132**, a second receiver **114** is coupled to a second BDM **134**, a third receiver **116** is coupled to a third BDM **136**, a fourth receiver **118** is coupled to a fourth BDM **138**, a fifth receiver **120** is coupled to a fifth BDM **140**, a sixth receiver **122** is coupled to a sixth BDM **142**, and a seventh receiver **124** is coupled to a seventh BDM **144**. Each of the BDMs **130** may be configured to generate an output (e.g., outputs **152-164**) that may be used by the processor **102** to predict an expected blockage of a signal path between a source of the signal and one or more of the plurality of receivers **110**. In a particular embodiment, the clock signal **150** may be provided to each of the BDMs **130** rather than to the plurality of receivers **110**. In another particular embodiment, the clock signal **150** may be provided to each of the BDMs **130** and the plurality of receivers **110**.

In an embodiment, each of the BDMs **130** includes a delay locked loop (DLL) and the processor **102** may determine whether the signal path is blocked based on a discriminator output of each of the DLLs. To illustrate, a transmitter may transmit a signal (e.g., an ultrasound signal) capable of being received or otherwise detected by a first selected receiver (e.g., the first receiver **112**). The signal may be detected by the first selected receiver (e.g., the first receiver **112**) and provided as an input to a DLL (e.g., a DLL within the first BDM **132**) coupled to the first selected receiver. When a signal path between the transmitter and the first selected receiver is unobstructed (i.e., there is a direct line of sight (LOS) between the transmitter and the first selected receiver), a discriminator output of the DLL may be zero, as shown in FIG. **20**. When the signal path between the transmitter and the first selected receiver is at least partially blocked, the DLL (e.g., the DLL within the first BDM **132**) may attempt to track a multipath signal instead of the direct LOS signal. The multipath signal may cause a tracking bias in the discriminator output of the DLL, as shown in FIG. **21**. The tracking bias may cause the discriminator output of the DLL to be non-zero. An exemplary DLL suitable for use in the device **100** is described with reference to FIG. **19**.

The output of the BDMs **130** may be used by the processor **102** to predict the expected blockage of the signal path between the source of the signal and the first selected receiver. For example, each of the BDMs **130** corresponding to a selected receiver (e.g., a receiver of the first set of receivers) may provide an output (e.g., a discriminator output of a DLL) to the processor **102**. The processor **102** may predict an expected blockage of a signal path between a source of the signal and one or more selected receivers (e.g., one or more of the first set of receivers) of the plurality of receivers **110** based on the outputs received from the BDMs **130** that correspond to the one or more selected receivers. The processor **102** may determine whether to de-select one or more of the selected receivers based on the prediction, and may determine whether to select one of the non-selected receivers (e.g., a receiver of the second set of receivers) for use in determining the location of the device transmitting the signal.

In another embodiment, each of the BDMs **130** includes a phase locked loop and the processor **102** may determine whether a signal path between a source of a signal and a first selected receiver is blocked based on an output of the PLL. For example, when the signal path is not blocked, an output of the PLL may be zero. When the signal path is at least partially blocked, the PLL may attempt to track a multipath signal. The multipath signal may cause loop stress that in turn causes the output of the PLL to be non-zero. The loop stress may also be referred to as a static phase error. An exemplary PLL may include a phase detector that includes a discriminator and other elements (e.g., a multiplier, a voltage controlled oscillator (VCO), etc.) to generate a change of phase output instead of a change in time output. The output of each of the PLLs (e.g., a PLL within each of the BDMs **130**) corresponds to a phase difference between the signal received at a selected receiver and the VCO may be provided to the processor **102**. In a particular embodiment, the output of the PLL may indicate a phase difference between the clock signal **150** and a clock signal associated with the signal received at the selected receiver. The processor **102** may predict an expected blockage of a signal path between a source of the signal and one or more of the selected receivers (e.g., the first set of receivers) based on the received phase outputs. In an embodiment, when the phase output of a particular PLL (i.e., a particular one of the BDMs **130**) is zero, the prediction may indicate that a selected receiver coupled to the particular PLL is not expected to be blocked. In this embodiment, when the phase output of the particular PLL is non-zero, the prediction may indicate an expected blockage of the selected receiver coupled to the particular PLL. The processor **102** determines whether to de-select one or more of the selected receivers (e.g., one or more of the first set of receivers) based on the prediction, and determines whether to select one of the non-selected receivers (e.g., a receiver of the second set of receivers) to for use in determining the location of the device transmitting the signal.

In yet another embodiment, each of the BDMs **130** may generate an output that indicates a signal to noise ratio (SNR). Each of the BDMs **130** may determine the SNR based on a ratio of a receiver signal to receiver noise at a particular one of the plurality of receivers, a ratio of a phase of the signal to the phase noise of the signal, a ratio of the phase of the signal to the phase noise of a PLL, a ratio of the PLL output to the phase noise of the PLL, another ratio, or a combination of ratios. The processor **102** may determine whether a signal path between the source of the signal and a first selected receiver is blocked based on the output. For example, the processor **102** may compare an SNR value indicated by the output of each of the BDMs **130** to a threshold value. When the SNR value associated with a particular selected receiver is greater than the threshold value, the processor **102** may predict that the signal path is not blocked (i.e., there is direct line of sight (LOS) along a signal path between the source of the signal and the particular selected receiver). When the SNR value associated with the particular selected receiver is less than the threshold value, the processor **102** may predict that the signal path is at least partially blocked (i.e., there is not direct LOS). The processor **102** may determine whether to de-select one or more of the selected receivers (e.g., one or more of the first set of receivers) based on the prediction, and may determine whether to select one of the non-selected receivers (e.g., one of the second set of receivers) for use in determining the location of the device transmitting the signal.

In an embodiment, at least one of the plurality of receivers **110** is a non-selected receiver and may not receive power. In this embodiment, at least one of the BDMs **130** corresponding to the at least one non-selected receiver may not receive power. By not providing power to the non-selected receivers (e.g., the second set of receivers) and the BDMs corresponding to the non-selected receivers, energy usage of the device **100** may be reduced relative to embodiments where the device **100** provides power to each of the plurality of receivers **110** irrespective of which of the plurality of receivers **110** are selected for use in determining the location of the device transmitting the signal.

For example, as shown in Table 1, in a first configuration (e.g., CONFIG-**1**), receivers **112**, **116**, **122**, and **124** may be selected receivers (e.g., a first set of receivers) and receivers **114**, **118**, and **120** may be non-selected receivers (e.g., a second set of receivers). The selected receivers **112**, **116**, **122**, **124** may detect a signal. Each of the selected receivers **112**, **116**, **122**, **124** provides a received signal to a BDM coupled to the selected receiver. For example, the first receiver **112** may provide a signal to the first BDM **132**, the third receiver **116** may provide a signal to the third BDM **136**, the sixth receiver **122** may provide a signal to the sixth BDM **142**, and the seventh receiver **124** may provide a signal to the seventh BDM **144**. Outputs of the BDMs **132**, **136**, **142**, **144** may be provided to the processor **102**. The processor **102** may predict an expected blockage of a signal path between a source of the signal and one of the selected receivers **112**, **116**, **122**, **124**. For example, if the outputs of the BDMs **132**, **136**, **142**, **144** have values of 0, 0.3, 0, and 0 respectively, the processor **102** may predict an expected blockage of the signal path between the source of the signal and the third receiver **116**.

TABLE 1

Sample configuration data stored in the look-up table 108		
Configuration #	Selected Receivers	Non-Selected Receivers
CONFIG-1	112, 116, 122, 124	114, 118, 120
CONFIG-2	112, 120, 122, 124	114, 116, 118
CONFIG-3	112, 116, 120, 124	114, 118, 122
CONFIG-4	116, 120, 122, 124	112, 114, 118
CONFIG-5	112, 114, 116, 122	118, 120, 124
CONFIG-6	112, 114, 120, 122	116, 118, 124
CONFIG-7	112, 114, 116, 120	118, 122, 124
CONFIG-8	114, 116, 120, 122	112, 118, 124
CONFIG-9	112, 114, 116, 124	118, 120, 122

In response to predicting an expected blockage of a signal path between the source of the signal and the third receiver **116**, the processor **102** may select at least one of the non-selected receivers (e.g., one of the second set of receivers) for use in determining the location of the device transmitting the signal. For example, the processor **102** may select one of the receivers **114**, **118**, **120**. Additionally, in response to predicting the expected blockage of the selected receiver, the processor **102** may de-select the selected receiver (e.g., the third receiver **116**).

In a particular embodiment, the processor **102** may select one of the non-selected receivers (e.g., one of the second set of receivers) by determining whether a signal path between the source of the signal and a particular non-selected receiver is blocked. In an embodiment, the processor **102** may cause the device **100** to activate (e.g., provide power to) the non-selected receiver prior to determining whether the signal path is blocked. In an embodiment, when the processor **102** de-selects a selected receiver, the processor **102** may cause the device **100** to deactivate (e.g., stop providing power to) the de-selected receiver.

In another embodiment, the processor **102** may retrieve data from a look-up table **108** to determine which of the non-selected receivers (e.g., one of the non-selected receivers **114**, **118**, **120**) to select. The look-up table **108** may store data identifying a current configuration of the receivers **112-124**. For example, each of the receivers **112-124** may be selected (e.g., included in the first set of receivers) or non-selected (e.g., included in the second set of receivers). In a particular embodiment, when a receiver (e.g., the first receiver **112**) is selected, the receiver is listening for a signal (e.g., an ultrasound signal). In this particular embodiment, when a receiver (e.g., the second receiver **114**) is non-selected, the receiver is not listening for the signal and may not be used by the processor **102** to determine a location of the device transmitting the signal.

In an exemplary embodiment, the data in Table 1 may be stored in the look-up table **108**. In response to predicting the expected blockage of the third receiver **116**, the processor **102** may retrieve data from the look-up table **108** (e.g., the data in Table 1). The data may indicate that a current selected receiver configuration is CONFIG-**1** of Table 1. In response to predicting the expected blockage of the signal path between the source of the signal and the third receiver **116**, the processor **102** may identify CONFIG-**2** as a next selected receiver configuration. By switching from CONFIG-**1** to CONFIG-**2**, the third receiver **116** (i.e., the receiver predicted to be blocked) is de-selected and becomes a non-selected receiver and the fifth receiver **120** is selected and becomes a selected receiver. The processor **102** may store information identifying a current selected receiver configuration (e.g., CONFIG-**2** of Table 1) in the look-up table **108**. By selecting only a subset of the plurality of receivers **110**, the device **100** achieves more efficient power and resource consumption. Additionally, by predicting a blockage of a signal path to a first selected receiver, the processor **102** is able to select a non-selected receiver as a second selected receiver prior to the blockage of the signal path between the source of the signal and the first selected receiver. The signal path between the source of the signal and the second selected receiver may not be blocked, and the signal is not lost.

In an embodiment, each time the device **100** is powered on, all of the receivers **112-124** are selected receivers. Each of the receivers **112-124** may receive a signal and provide data associated with the received signal to the processor **102**. The processor **102** may receive the data and determine whether to de-select one or more of the receivers **112-124**. The processor **102** may store configuration information identifying which of the receivers **112-124** are selected receivers (e.g., a first set of receivers) and which of the receivers **112-124** are non-selected receivers (e.g., a second set of receivers) in the look-up table **108** of the memory **104**.

In another embodiment, each time the device **100** is powered on, the processor **102** may retrieve a default configuration from the look-up table **108**. The default configuration may identify a default state (i.e., selected or non-selected) for each of the receivers **112-124**. In response to retrieving the default configuration information, the processor **102** may select a subset of the receivers **112-124** as selected receivers (e.g., a first set of receivers) based on the default configuration information. For example, the default configuration may indicate that the receivers **112-118** are to be selected receivers and that the receivers **120-124** are to be non-selected receivers (e.g., a second set of receivers). After each of the receivers **112-124** is placed in the state identified by the default configuration, the selected receivers may listen for signals (e.g., ultrasound signals). As the selected receivers detect and process the signals, information associated with the signals is provided to the processor **102**. The processor **102** may modify a state (i.e., select and/or de-select) of one or more of the receivers **112-124** based on the information associated with the signals. For example, the processor **102** may select a first receiver that was previously a non-selected receiver in response to predicting an expected blockage of one of the selected receivers. The processor **102** may de-select the selected receiver that was predicted to be blocked.

In the particular embodiment illustrated in FIG. **1**, the device **100** includes seven receivers (e.g., the receivers **112-124**). In other embodiments, the device may include more than or fewer than seven receivers. In an embodiment, each of the receivers **112-124** is operable to detect an ultrasound signal transmitted from an ultrasound transmitter. In another embodiment, a first group of the receivers **112-124** is operable to detect and process ultrasound signals and a second group of the receivers **112-124** is operable to detect and process analog or other audio signals (e.g., voice signals). In yet another illustrative embodiment, a first group of the receivers **112-124** may be dedicated to detecting and processing ultrasound signals, a second group of the receivers **112-124** may be dedicated to detecting and processing analog signals (e.g., voice signals), and a third group of the receivers **112-124** may be operable to detect and process both ultrasound signals and analog or audio signals (e.g., voice signals). In a particular embodiment, the plurality of receivers **112-124** includes at least one receiver (e.g., a microphone) that is configured to detect acoustic signals (e.g., ultrasound signals) outside of a human auditory range and to detect acoustic signals (e.g., audio signals) within the human auditory range. In a particular embodiment, the ultrasound signal may correspond to an acoustic signal that is outside of a human auditory range (i.e., signals having a frequency in excess of twenty (20) kHz) and the analog or audio signal may correspond to an acoustic signal that is within the human auditory range (e.g., signals having a frequency between twenty (20) Hertz (Hz) and twenty (20) kHz).

In an embodiment, the signals may be used by the processor **102** to determine a position of an object relative to the device **100**. While not shown in FIG. **1**, the signals received at the selected receivers (e.g., the first set of receivers) may be provided to the processor **102**. Additionally, the BDM **130** outputs **152-164** may be provided to a system clock of the device **100** in order to synchronize the clock signal **150** with another clock signal associated with the signals received at the selected receivers. When the system clock of the device **100** is synchronized with the other clock signal, the processor **102** may use the signals received at the selected receivers to determine the position of the object using time difference of arrival (TDOA).

Referring to FIG. **2**, an illustrative embodiment of a stylus pen **202** suitable for use with the device **100** is shown. The stylus pen **202** includes a transmitter **204**. In a particular embodiment, the transmitter **204** is an ultrasound transmitter. The transmitter **204** transmits a signal responsive to a clock signal **206**. The clock signal **206** may be generated by a clock (CLK) within the stylus pen **202**. For example, the transmitter **204** may transmit a signal including data determined based on the clock signal **206**. The signal may be detected by a selected receiver of the device **100**. The signal may be processed (e.g., by a BDM corresponding to the selected receiver) as described with reference to FIG. **1** and the processed signal may be used by the processor **102** in calculating the position of the stylus pen **202** relative to the device **100**. The processor **102** may calculate the position of the stylus pen **202** using time difference of arrival (TDOA).

Referring to FIGS. **3**A and **3**B, an illustrative embodiment of an apparatus **302** is shown. In FIG. **3**A, a front view **300** of the apparatus **302** is shown. In FIG. **3**B, a rear view **324** of the apparatus **302** is shown. In an illustrative embodiment, the apparatus **302** may be a tablet computer, a laptop computer, a wireless communication device, another computing device, or any combination thereof. For example, the apparatus **302** may correspond to the device **100** of FIG. **1**. The apparatus **302** includes a plurality of receivers **304**, **306**, **308**, **310**, **312**, **314**, **326**. The apparatus **302** may include a transmitter **316**. Additionally, the apparatus **302** may include speakers **318**, **320** and a display screen **322**. The plurality of receivers **304**, **306**, **308**, **310**, **312**, **314**, **326** may be operable to receive a signal. In an embodiment, one or more of the plurality of receivers **304**, **306**, **308**, **310**, **312**, **314**, **326** may be a microphone. In another embodiment, one or more of the receivers **304**, **306**, **308**, **310**, **312**, **314**, **326** may be a transducer. Each of the plurality of receivers **304**, **306**, **308**, **310**, **312**, **314**, **326** may be configured to receive an audio signal (e.g., voice), an ultrasound signal, or any combination thereof.

In the embodiment illustrated in FIGS. **3**A and **3**B, the apparatus **302** includes seven receivers. In other embodiments, the apparatus **302** includes at least three receivers, at least four receivers, or another number of receivers. The apparatus **302** may be configured to select some of the receivers **304**, **306**, **308**, **310**, **312**, **314**, **326**. For example, the apparatus **302** may include a processor (e.g., the processor **102**) configured to predict an expected blockage of a signal path between a source of a signal (e.g., the transmitter **204**) and a selected receiver (e.g., a receiver of a first set of receivers). The processor of the apparatus **302** may predict the expected blockage based on input received from blockage detection mechanisms (BDMs) as described with reference to FIG. **1**. In response to predicting the expected blockage of the selected receiver, the apparatus **302** may predict whether a signal path between the source of the signal and a non-selected receiver (e.g., a receiver of a second set of receivers) is expected to be blocked. If the signal path between the source of the signal and the non-selected receiver is not predicted to be blocked, the apparatus **302** may de-select the selected receiver and select the non-selected receiver. By dynamically selecting a subset of the receivers **304**, **306**, **308**, **310**, **312**, **314**, **326** for use in determining the position of the device transmitting the signal, the apparatus **302** may consume less power than if all the receivers **304**, **306**, **308**, **310**, **312**, **314**, **326** were used to determine the position of the device transmitting the signal.

Referring to FIG. **4**, a system **400** is shown. A coordinate system **401** is illustrated and includes an x-axis **402**, a y-axis **404**, and a z-axis **406**. In an illustrative embodiment, the stylus pen **202** may communicate with the apparatus **302** using a signal emitted from the transmitter **204**. For example, the stylus pen **202** may be used to write on the display screen **322** of the apparatus **302**. As another example, the stylus pen **202** may be used to select an icon (not shown) that is displayed on the display screen **322** of the apparatus **302**. The apparatus **302** may determine a location of the stylus pen **202** based on signals received by the receivers **304**, **306**, **308**, **310**, **312**, **314**, **326**, or a subset of the receivers **304**, **306**, **308**, **310**, **312**, **314** from the transmitter **204** of the stylus pen **202**.

The apparatus **302** may be configured to determine a 2-dimensional (2D) location of the stylus pen **202** within a plane of the display screen **322**. For example, an icon displayed on the display screen **322** may be selected using the stylus pen **202** by tapping the stylus pen **202** on a portion of the display screen **322** corresponding to the icon. In an illustrative embodiment, the apparatus **302** may maintain at least three of the receivers **304**, **306**, **308**, **310**, **312**, **314** as selected receivers for use in determining the 2D location of the stylus pen **202**.

As another illustrative example, the apparatus **302** may determine the 3-dimensional (3D) location of the stylus pen **202** in relation to the apparatus **302** (e.g., a location with reference to the x-axis **402**, the y-axis **404**, and the z-axis **406**). For example, the icon displayed on the display screen **322** may be selected by placing the stylus pen **202** within a threshold distance (e.g., a distance along the y-axis **404** above the plane of the x-axis **402** and the z-axis **406**) of the portion of the display screen **322** corresponding to the icon. In an illustrative embodiment, the apparatus **302** may maintain at least four of the receivers **304**, **306**, **308**, **310**, **312**, **314** as selected receivers for use in determining the 3D location of the stylus pen **202**.

Referring to FIG. **5**A, an illustrative embodiment of a side view **540** of the apparatus **302** is shown. As shown in FIG. **5**A, the apparatus **302** includes receivers **502**, **504**, and **506**. Receiver **502** may correspond to the receivers **304**, **308**, **310**, and **312** of FIG. **3**A (as seen from the side view **540**). Receiver **504** may correspond to the receiver **306** of FIG. **3**A, and receiver **506** may correspond to receiver **314** of FIG. **3**A. Receiver **326** of FIG. **3**B is not shown for simplicity of illustration.

As shown in FIG. **5**A, the transmitter **204** of the stylus pen **202** may transmit a signal that may travel along a plurality of signal paths **510**, **512**, **514** to the receivers **502**, **504**, **506**. The stylus pen **202**, and in particular the transmitter **204**, may be located at a distance **520** from the apparatus **302**. The distance **520**, as illustrated in FIG. **5**A, may correspond to a distance in the direction of the y-axis **404** of FIG. **4**.

Referring to FIG. **5**B, a front view **550** of the apparatus **302** is shown. The front view **550** of FIG. **5**B illustrates the plurality of signal paths **510**, **512**, **514** of FIG. **5**A. In FIG. **5**B, the plurality of signal paths **522**, **524**, **526**, **528** may correspond to the signal path **510**. A signal emitted from the transmitter **204** may propagate along the signal paths **522**, **524**, **526**, **528** and may be received at the receivers **304**, **308**, **310**, **312** of the apparatus **302**. The signal path **532** may correspond to the signal path **512**. A signal emitted from the transmitter **204** may propagate along the signal path **532** and may be received at the receiver **306**. The signal path **530** may correspond to the signal path **514**. A signal emitted from the transmitter **204** may propagate along the signal path **530** and may be received at the receiver **314**. In an embodiment, the signal may originate at the transmitter **204** of the stylus pen **202**. In an alternative embodiment, the signal may originate at the transmitter **316** of the apparatus **302** and may be reflected by the stylus pen **202**. The reflected signal may propagate along the signal paths **522**-**532**.

Referring to FIG. **6**A, an illustrative example of receiving a signal from the transmitter **204** is shown. As shown in FIG. **6**A, the transmitter **204** of the stylus pen **202** may transmit a signal that travels along the signal path **510** and is received at a particular receiver of the receivers **502**. The particular receiver of the receivers **502** is a selected receiver. In FIG. **6**A, the signal path **510** is an unobstructed path to the particular receiver of the receivers **502**.

Referring to FIG. **6**B, another illustrative example of receiving a signal from the transmitter **204** is shown. As shown in FIG. **6**B, the transmitter **204** of the stylus pen **202** may transmit a signal that propagates along the signal path **510** and is received at a particular receiver of the receivers **502**. The particular receiver of the receivers **502** is a selected receiver. In FIG. **6**B, a blocking object **616** is shown. The blocking object **616** may block or obstruct a portion **618** of the signal path **510** as a result of movement of the blocking object **616**, as a result of movement of the transmitter **204**, or both. A strength of the signal received by the receiver **502** in FIG. **6**B may be less than a strength of the signal received at the particular receiver of the receivers **502** in FIG. **6**A due to the blocking object **616** blocking the portion **618** of the signal path **510**.

The particular receiver of the receivers **502** illustrated in FIG. **6**B may be coupled to a blockage detection mechanism (BDM) configured to generate an output based on the signal received at the particular receiver. The output may be provided to a processor (not shown) of the device **302** and may be used by the processor to predict an expected blockage of the signal path **510** as described with reference to FIG. **1**. In a particular embodiment, the BDM coupled to the particular receiver may generate an output indicating a signal to noise ratio (SNR) value of the signal received at the particular receiver. In another embodiment, the BDM may include a delay locked loop (DLL) or a phase locked loop (PLL) and an output of the DLL or PLL may be used by the processor to predict an expected blockage of the signal path **510**, as described with reference to FIG. **1**. In yet another embodiment, the BDM may generate an output that includes information associated with an SNR value and information associated with an output of a DLL or a PLL. The processor may predict an expected blockage of the signal path **510** based on the information associated with the SNR value and based on the information associated with the output of the DLL or the PLL, as described with reference to FIG. **1**.

Referring to FIG. **6**C, another illustrative example of receiving a signal from the transmitter **204** is shown. As shown in FIG. **6**C, the transmitter **204** of the stylus pen **202** may transmit a signal that travels along a portion of the signal path **510**. In FIG. **6**C, the blocking object **616** is shown. The blocking object **616** is blocking a second portion **620** of the signal path **510**. As shown in FIG. **6**C, the second portion **620** indicates that substantially the entire signal is blocked from reaching the particular receiver of the receivers **502** via the signal path **510**. Thus, the strength of the signal may be too weak to be detected at the particular receiver and the signal may be lost, which may prevent the apparatus **302** from accurately determining a location of the source of the signal (e.g., the transmitter **204**).

The apparatus **302** may be operable to predict the expected blockage of the second portion **620** of the signal path **510** prior to losing the signal. For example, the apparatus **302** may detect that the portion **618** of the signal path **510** has been blocked or obstructed by the blocking object **616**, as shown in FIG. **6**B. In response to detecting that the portion **618** of the signal path **510** has been blocked, the apparatus **302** may predict the expected blockage of the second portion **620** of the signal path **510**. In response to predicting the expected blockage of the second portion **620** of the signal path **510**, the apparatus **302** may select a non-selected receiver prior to the blocking object **616** blocking the second portion **620** of the signal path **510**. By selecting a non-selected receiver capable of receiving the signal along a signal path that is not predicted to be blocked or otherwise obstructed, the apparatus **302** may prevent the loss of the signal that would otherwise occur when the blocking object **616** blocks the second portion **620**. Thus, the apparatus **302** is able to maintain a sufficient number of selected receivers to determine a location of a source of the signal and select a non-selected receiver in response to a predicted blockage of a selected receiver.

Referring to FIG. **7**A, the front view **550** of FIG. **5**B is shown. The front view **550** of FIG. **7**A illustrates the plurality of signal paths **522**-**532** of FIG. **5**B. As shown in FIG. **7**A, a signal originating at the transmitter **204** of the stylus pen **202** may propagate along the plurality of signals paths **522**-**532** to the receivers **304**, **306**, **308**, **310**, **312**, **314**. Alternatively, a signal originating at another source may be reflected by the stylus pen **202** and the reflected signal may propagate along the signals paths **522**-**532**. As explained with reference to FIG. **1**, the apparatus **302** may maintain only some of the receivers **304**-**314** as selected receivers (e.g., a first set of receivers) and others of the receivers **304**-**314** as non-selected receivers (e.g., a second set of receivers). FIG. **7**A illustrates the signal paths **522**-**532** along which the signal may propagate. The signal may be received at the selected receivers while the non-selected receivers may not receive the signal. As shown in FIG. **7**A, a first receiver **304**, when selected, receives the signal via a first signal path **522**, a second receiver **306**, when selected, receives the signal via a second signal path **532**, a third receiver **308**, when selected, receives the signal via a third signal path **524**, a fourth receiver **310**, when selected, receives the signal via a fourth signal path **526**, a fifth receiver **312**, when selected, receives the signal via a fifth signal path **528**, and a sixth receiver **314**, when selected, receives the signal via a sixth signal path **530**.

Referring to FIG. **7**B, an illustrative embodiment of the front view **550** of the apparatus **302** is shown. In FIG. **7**B, the receivers **304**-**314** are configured according to a particular receiver configuration corresponding to CONFIG-**1** of Table 1. The receivers **112**-**124** of Table 1 may correspond to the receivers **304**-**314** of FIGS. **3**A and **7**A. For example, the first receiver **112** may correspond to the first receiver **304**, the second receiver **114** may correspond to the second receiver **306**, the third receiver **116** may correspond to the third receiver **312**, the fourth receiver **122** may correspond to the fourth receiver **308**, the fifth receiver **120** may correspond to the fifth receiver **314**, the sixth receiver **124** may correspond to the sixth receiver **310**, and the seventh receiver **118** may correspond to a seventh receiver (not shown in the front view **550**) that corresponds to the seventh receiver **326** of FIG. **3**B. As described with reference to Table 1, CONFIG-**1** indicates that the receivers **304**, **308**, **310**, **312** are selected receivers (e.g., a first set of receivers) and that the receivers **306**, **314**, **326** are non-selected (e.g., a second set of receivers). Accordingly, the selected receivers **304**, **308**, **310**, **312** may be receiving the signal that propagates along corresponding signal paths **522**, **524**, **526**, **528**. The signal paths **530**, **532** are not shown in FIG. **7**B because non-selected receivers **306**, **314** are not receiving the signal.

As illustrated in FIG. **7**B, a blocking object **700** may block or otherwise obstruct at least a portion of one of the signal paths, such as the signal path **528**. For example, at a first time the blocking object **700** may be blocking only a portion of the signal path **528** as illustrated by the portion **618** of FIG. **6**B. The blocking object **700** may cause a change in value output by a BDM coupled to the receiver **312**. A processor (e.g., the processor **102**) may predict an expected blockage of the signal path **528** based on the value output by the BDM coupled to the receiver **312**. The processor may select a non-selected receiver (e.g., one of the non-selected receivers **306**, **314**) for use in determining a location of a device transmitting the signal in response to predicting the expected blockage of the signal path **528**.

For example, in response to predicting an expected blockage of the signal propagating along signal path **528**, the processor may determine that the sixth receiver **314** (e.g., corresponding to the fifth receiver **120** of Table 1) should be selected (i.e., included in the first set of receivers) and that the fifth receiver **312** (e.g., corresponding to the third receiver **116** of Table 1) should be de-selected (i.e., included in the second set of receivers). In an embodiment, the processor may determine that the sixth receiver **314** should be selected by performing a look-up using data retrieved from a look-up table (e.g., the look-up table **108** of FIG. **1**) as described with reference to FIG. **1**. In response to determining that the sixth receiver **314** should be selected, the processor may initiate a configuration change to CONFIG-**2** of Table 1. As shown in CONFIG-**2** of Table 1, the third receiver **116** (e.g., corresponding to the fifth receiver **312** of FIG. **3**A) is a non-selected receiver and the fifth receiver **120** (e.g., corresponding to the sixth receiver **314** of FIG. **3**A) is a selected receiver.

In another embodiment, the processor may determine that the sixth receiver **314** should be selected by temporarily selecting the sixth receiver **314** and predicting an expected blockage of the sixth receiver **314** based on an output of a blockage detection mechanism (BDM) coupled to the sixth receiver. In a particular embodiment, temporarily selecting the sixth receiver **314** may include temporarily providing power to the sixth receiver **314** and the BDM coupled to the sixth receiver **314**. The processor may determine that the sixth receiver **314** should remain selected when the prediction indicates that the sixth receiver **314** is not predicted to be at least partially blocked. When the prediction indicates that the sixth receiver **314** is predicted to be at least partially blocked, the processor may de-select the sixth receiver and temporarily select another receiver (e.g., the second receiver **306**) to predict an expected blockage of the other receiver. The processor may continue this process to identify one of the receivers **306**, **312**, **314** that is predicted to be unblocked or not completely blocked and maintain the identified receiver as a selected receiver while the other receivers may be maintained as non-selected receivers.

At a second time, the blocking object **700** may be entirely blocking the signal path **528**. Prior to the blocking object **700** entirely blocking the signal path **528**, the processor may select the one of the non-selected receivers (e.g., the sixth receiver **314**) and may de-select the fifth receiver **312**. As shown in FIG. **7**B, the signal may be reflected by the blocking object **700** along a reflection path **702** and the fifth receiver **312** may be unable to receive the signal along the signal path **528**. Without a signal received by the fifth receiver **312**, the apparatus **302** may be unable to determine or track a 3-dimensional (3D) location of the transmitter **204**. By selecting the sixth receiver **314**, the apparatus **302** is able to continue determining or tracking the 3D location of the transmitter **204**.

In an embodiment, the apparatus **302** may be configured to determine the 3D location of the transmitter **204** using four or more selected receivers. If the processor, in response to predicting an expected blockage of one of the selected receivers, is unable to identify a non-selected receiver to select for use in determining the location of the transmitter **204** (e.g., all of the non-selected receivers are blocked or being used for other purposes), the processor may transition to a 2-dimensional (2D) location determination mode that enables the apparatus **302** to determine a 2D location of the transmitter **204** with fewer selected receivers (e.g., three or more active receivers). If, at a subsequent time, one of the non-selected receivers that was blocked becomes unblocked, the processor may select the unblocked non-selected receiver for use in determining the location of the transmitter **204** and transition the device back into the 3D location determination mode.

As illustrated in FIG. **7**B, the reflection path **702** may cause the signal to be reflected to another receiver of the plurality of receivers **304**-**314**. For example, the signal may be reflected by the blocking object **700** along the reflection path **702**. When the sixth receiver **314** is a selected receiver, the reflected signal may be at least partially received at the sixth receiver **314** (as a multipath signal) along with the signal from the transmitter **204** propagating along signal path **530**. Because the sixth receiver **314** has a line of sight path to the transmitter **204** (e.g., the source of the signal), the multipath signal may not create tracking bias in a BDM **103** coupled to the sixth receiver **314**.

Referring to FIG. **7**C, the blocking object **700** has moved (relative to its previous location depicted in FIG. **7**B) and is at least partially blocking the signal path **526** (corresponding to the fourth receiver **310**) and the signal path **528** (corresponding to the fifth receiver **312**). As shown in FIG. **7**C, receivers **304**, **308**, **310**, and **314** are selected receivers and may be receiving the signal propagating along corresponding signal paths **522**, **524**, **526**, **530**. The signal propagating along signal path **528** is at least partially blocked and the fifth receiver **312** is a non-selected receiver, as described above with reference to FIG. **7**B. Additionally, because the signal propagating along signal path **526** is at least partially blocked by the blocking object **700**, the processor may predict an expected blockage of the fourth receiver **310**.

As explained with reference to FIG. **7**B, at a first time receivers **304**, **308**-**312** were selected receivers. In response to the blocking object **700** blocking at least a portion of the signal path **528** corresponding to the fifth receiver **312**, the processor selected the sixth receiver **314** and de-selected the fifth receiver **312**. Thus, at a second time the selected receivers included the receivers **304**, **308**, **310**, **314**. As shown in FIG. **7**C, the signal path **526** corresponding to the fourth receiver **310** is at least partially blocked. As a result, the processor may predict an expected blockage of the signal path **526** and select a non-selected receiver, such as the second receiver **306**. Additionally, the processor may de-select the fourth receiver **310**. The fifth receiver **312** may remain a non-selected receiver, for example, because the signal path **528** remains at least partially blocked by the blocking object **700**.

Referring to FIG. **7**D, the blocking object **700** has moved (from its previous location in FIG. **7**C) and is blocking the signal path **524** (corresponding to the third receiver **308**) and the signal path **526** (corresponding to the fourth receiver **310**). In FIG. **7**D, the receivers **304**, **306**, **308**, **314** are selected receivers. The signal traveling along signal path **524** may be reflected along a reflection path **706**. As illustrated in FIG. **7**D, the signal propagating along signal path **524** is at least partially blocked by the blocking object **700**. The at least partial blockage of the signal path **524** may cause the processor to predict an expected blockage of the third receiver **308**. In response to predicting the expected blockage of the third receiver **308**, the processor may identify a non-selected receiver (e.g. one of the receivers **308**, **312**) for use in determining the location of the transmitter **204** (i.e., as a selected receiver).

In FIG. **7**D, the signal path **528** is not shown because the fifth receiver **312** is a non-selected receiver. In FIG. **7**D, the signal path **528** corresponding to the fifth receiver **312** may no longer be blocked by the blocking object **700**. The processor may determine that the fifth receiver **312** should be selected for use in determining the location of the transmitter **204** and may select the fifth receiver **312** and de-select the third receiver **308**.

Thus, FIGS. **7**A-**7**D show an apparatus **302** that is operable to select and de-select each of a plurality of receivers based on predicted blockages of signal paths between a signal source and each of the plurality of receivers. By predicting an expected blockage of a signal path by a blocking object (e.g., a user's hand), the apparatus **302** may be able to select an additional receiver (e.g., a non-selected receiver) for use in determining the location of the transmitter **204** prior to loss of the signal. By selecting and de-selecting receivers based on expected blockage predictions, the apparatus **302** is able to maintain a sufficient number of selected receivers for use in determining the location of the source of the signal while reducing power consumption of the apparatus **302**.

Referring to FIG. **8**, another illustrative embodiment of a system capable of detecting a location of a transmitter (or a device that includes a transmitter) is shown. In FIG. **8**, a first apparatus **802**, a second apparatus **804**, and a third apparatus **806** are shown. In the illustrative embodiment, each of the apparatuses **802**, **804**, **806** may correspond to the apparatus **302** of FIGS. **3**A and **3**B. While three apparatuses are shown in FIG. **8**, in some embodiments, more than three or fewer than three apparatuses may be used.

As illustrated in FIG. **8**, the apparatus **802** includes a transmitter **802**T, a display screen **810**, and receivers **840**-**850**; the apparatus **804** includes a transmitter **804**T, a display screen **820**, and receivers **852**-**862**; and the apparatus **806** includes a transmitter **806**T, a display screen **810**, and receivers **864**-**874**. In FIG. **8**, each of the transmitters **802**T, **804**T, **806**T may transmit a signal. For example, the transmitter **802**T may transmit a signal **802**S, the transmitter **804**T may transmit a signal **804**S, and the transmitter **806**T may transmit a signal **806**S. Each of the signals **802**S, **804**S, **806**S may be unique to its respective transmitter **802**T, **804**T, **806**T. The signals **802**S, **804**S, **806**S may be received at a plurality of active receivers located at each of the apparatuses **802**, **804**, **806**. For example, when the apparatus **802** is operating in a 2D location detection configuration, the receivers **840**, **846**, and **850** may be selected receivers (e.g., a first set of receivers) and the receivers **842**, **844**, and **848** may be non-selected receivers (e.g., a second set of receivers). The selected receivers **840**, **846**, and **850** may receive the signal **804**S and the signal **806**S. The apparatus **802** may determine a location of the apparatus **804** and the apparatus **806** based on the signal **804**S and the signal **806**S received at the selected receivers **840**, **846**, and **850**.

Each of the apparatuses **802**, **804**, and **806** may be operable to determine a direction of each of the other apparatuses **802**, **804**, and **806** relative to itself. For example, the apparatus **802** may be operable to receive the signal **804**S from the transmitter **804**T and to determine a location (e.g., direction or direction and distance) of the apparatus **804** relative to the apparatus **802**. For example, in response to receiving the signal **804**S from the transmitter **804**T at the selected receivers **840**, **846**, and **850** (e.g., the first set of receivers), the apparatus **802** may determine that the apparatus **804** is located in a direction **812** relative to the apparatus **802**. Additionally, the apparatus **802** may determine that the apparatus **806** is located in a direction **814** relative to the apparatus **802** in response to receiving the signal **806**S from the transmitter **806**T at the selected receiver **840**, **846**, and **850**. The apparatus **802** may include a software application executable by a processor of the apparatus **802** to display an indicator of the direction of the apparatus **804** (e.g., the direction **812**), an indicator of the direction of the apparatus **806** (e.g., the direction **814**), or both on the display screen **810** of the apparatus **802**.

The apparatus **804** may be operable to receive the signal **802**S from the transmitter **802**T and determine a location (e.g., direction or direction and distance) of apparatus **802** relative to the apparatus **804**. For example, the receivers **860**, **854**, and **856** of the apparatus **804** may be selected receivers (e.g., a first set of receivers) and the receivers **852**, **858**, and **862** may be non-selected receivers (e.g., a second set of receivers). The selected receivers **860**, **854**, and **856** may receive the signal **802**S and the signal **806**S. The apparatus **804** may determine the location of the apparatus **802** and the apparatus **806** based on the signal **802**S and the signal **806**S received at the selected receivers **860**, **854**, and **856** (e.g., the first set of receivers). The apparatus **804** may determine that the apparatus **802** is located in a direction **822** relative to the apparatus **804** and that the apparatus **806** is located in a direction **824** relative to the apparatus **804**. The apparatus **804** may include a software application executable by a processor of the apparatus **804** to display an indicator of the directions **822**, **824** on the display screen **820** of the apparatus **804**.

The apparatus **806** may be operable to receive the signal **802**S from the transmitter **802**T and determine a location (e.g., direction or direction and distance) of the apparatus **802** relative to the apparatus **806**. For example, the apparatus **806** may be operating in a 3D location detection mode and the receivers **864**, **872**, **874**, and **866** of the apparatus **806** may be selected receivers (e.g., a first set of receivers). The receivers **868**, **870** may be non-selected receivers (e.g., a second set of receivers). The selected receivers **864**, **872**, **874**, and **866** may receive the signal **802**S and the signal **804**S. The apparatus **806** may determine the location of the apparatus **802** and a location of the apparatus **804** based on the signal **802**S and the signal **804**S received at the selected receivers **864**, **872**, **874**, and **866**. The apparatus **806** may determine that the apparatus **802** is located in a direction **832** relative to the apparatus **806** and that the apparatus **804** is located in a direction **834** relative to the apparatus **806**. The apparatus **806** may include a software application executable by a processor of the apparatus **806** to display an indicator of the directions **832**, **834** on the display screen **830** of the apparatus **806**.

The system illustrated in FIG. **8** is operable to indicate a direction of a source of a signal even when the source of the signal is not between or bounded by the selected receivers (e.g., the first set of receivers) of one of the apparatuses **802**, **804**, **806**. The apparatuses **802-806** may select and de-select receivers based on predictions of expected blockages as described with reference to FIG. **1-7**D. Local echoes (from its own transmitter) from each apparatus may be strong enough to interfere with signals transmitted from other devices. The local echoes may be canceled by using pre-measured or adaptively calculated direct path transfer functions between the transmitter and each of the receivers on that apparatus. Thus, the system of FIG. **8** is capable of providing object detection using a plurality of selected receivers while consuming less power than if all receivers were selected receivers.

Referring to FIG. **9**, a block diagram of a system **900** to determine a set of selected receivers and a set of de-selected receivers is shown. As shown in FIG. **9**, the system **900** includes a plurality of receivers, including a receiver n, a receiver n+1, a receiver n+2, and a receiver n+3. In a particular embodiment, the plurality of receivers may include more receivers than shown in FIG. **9** and it should be understood that only four receivers are shown in FIG. **9** for simplicity of description. Each of the plurality of receivers is coupled to a blockage detection mechanism (BDM). For example, the receiver n is coupled to a BDM **904**, the receiver n+1 is coupled to a BDM **906**, the receiver n+2 is coupled to a BDM **908**, and the receiver n+3 is coupled to a BDM **910**. In an embodiment, the BDMs coupled to each of the plurality of receivers may correspond to the BDMs **130** of FIG. **1**. For example, the BDMs **904-910** may include a DLL or a PLL configured to generate an output based on signals (e.g., ultrasound signals) received at a corresponding receiver (i.e., a receiver coupled to the BDM), as described with reference to FIG. **1**. As another example, each the BDMs **904-910** may be configured to generate an output based on a signal to noise ratio (SNR) associated with the signal received at a corresponding receiver. In a particular embodiment, each of the BDMs **904-910** may include a PLL or a DLL and the SNR is determined based on an output of the PLL or the DLL.

As shown in FIG. **9**, the system **900** includes a processor **902** configured to execute a prediction algorithm **912**. In a particular embodiment, the prediction algorithm **912** may be stored at a memory (not shown) as instructions executable by the processor **902**. In another embodiment, the processor **902** may include circuitry configured to execute the prediction algorithm. The prediction algorithm **912**, when executed by the processor **902** (or circuitry of the processor **902**) may cause the processor **902** to predict an expected blockage of one or more selected receivers and, in response to predicting an expected blockage of at least one of the one or more selected receivers, to select a non-selected receiver for use in determining a location of a source of the signal. The prediction algorithm **912**, when executed by the processor **902** (or circuitry of the processor **902**), may cause the processor **902** to de-select a selected receiver. For example, at a first time the system **900** includes a set of selected receivers **920**, including receiver n, receiver n+1, and receiver n+2. At the first time the receiver n+3 may be a non-selected receiver.

As shown in FIG. **9**, the prediction algorithm **912** may receive a plurality of inputs **942-950** including a use case input **942**, a mode input **944**, a BDM operation input **946**, a configuration input **948**, and a BDM type input **950**. To illustrate, referring to FIG. **10**, a table **1000** illustrating various prediction algorithm input values is shown. As shown in FIG. **10**, the table **1000** includes a use case column **1002**, a Blockage Detection Mechanism (BDM) Type column **1004**, a BDM Operator column **1006**, and a mode column **1008**. In a particular embodiment, the use case column **1002** may correspond to the use case input **942** described with reference to FIG. **9**. As shown in FIG. **10**, the use case input **942** may indicate a use case corresponding to a Non-pen use case **1024**, a Pen use case **1026**, and a Tablet use case **1028**. The Non-pen **1024** use case may correspond to when a device, such as the system **900**, is not interacting with an external device, such as the stylus pen **202**. The Pen use case **1026** may correspond to when the device is interacting with the external device. The Tablet use case **1028** may correspond to when the device is operating in a peer-to-peer positioning system and is determining the location of another device (e.g., another tablet device), as described with reference to FIG. **8**.

In a particular embodiment, the BDM Type column **1004** may correspond to the BDM Type input **950** of FIG. **9**. The BDM Type input **950** indicates a type of BDM output that is to be used to predict the expected blockage. The BDM Type input **950** may indicate whether the processor **902** is to predict the expected blockage of a particular receiver based on an output of a DLL or an output of a PLL (e.g., the BDM Type **1014**), a signal to noise ratio (SNR) associated with the signal received at a corresponding receiver (e.g., the BDM Type **1012**), or a SNR associated with an output of the DLL or the PLL (e.g., the BDM Type **1016**). For example, each of the BDMs **904-910** of FIG. **9** may include a DLL or a PLL, a SNR device, or a combination thereof, and may be configured to generate an output based on the DLL, the PLL, the SNR device, or a combination thereof. The BDM Type input **950** may indicate to the processor **902** whether the output of a particular BDM is generated based on the DLL, the PLL, the SNR device, or a combination thereof. The processor **902**, based on the BDM Type input **950**, may predict whether a particular receiver coupled to the particular BDM is expected to be blocked based at least in part on the type of BDM output.

In a particular embodiment, the BDM Operation column **1006** may correspond to the BDM Operation input **946** of FIG. **9**. The BDM operation input **946** may indicate that all receivers are to be powered (e.g., at BDM Operation **1018**) or that only selected receivers are to receive power (e.g., at BDM Operation **1020**). When the BDM operation input **946** indicates that all receivers are to be powered, the device (e.g., the system **900**) may provide power to each of the receivers (i.e., both selected and non-selected receivers are powered).

In a particular embodiment, the mode column **1008** may correspond to the Mode input **944** described with reference to FIG. **9**. The Mode input **944** may indicate a concurrency mode (e.g., at Mode **1030**), a normal mode (e.g., at Mode **1032**), or a quadmic mode (e.g., at Mode **1034**). The Mode input **944** may indicates indicate to the processor **902** how the configuration of selected receivers is to be changed in response to predicting an expected blockage of a particular selected receiver (i.e., one of the selected receivers **920**). For example, the system **900** may operate in a quadmic mode, a normal mode, or a concurrency mode. When operating in the quadmic mode, the system **900** may use four selected receivers to determine the location (e.g., for a 3-D location determination) of a source of a signal (e.g., the location of the stylus pen **202**). In response to predicting the expected blockage of at least one of the selected receivers **920**, the system **900** predicts whether a non-selected receiver is expected to be blocked. When the non-selected receiver is predicted to be unblocked, the processor **902** may select the non-selected receiver and de-select the at least one selected receiver predicted to be blocked. When the processor **902** predicts that each of the non-selected receivers is expected to be blocked, the processor **902** may change the mode to the normal mode.

When operating in the normal mode, the system **900** may use three selected receivers to determine the location (e.g., for a 2-D location determination) of the source of the signal. The processor **902** may continue to monitor the status of the non-selected receivers and predict whether one of the non-selected receivers is expected to be non-blocked. When the processor **902** determines that a particular one of the non-selected receivers is no longer predicted to be blocked, the processor **902** may select the particular one of the non-selected receivers and change the mode to the quadmic mode.

When the system **900** is operating in the concurrency mode (i.e., the Mode input **944** indicates concurrency mode **1030**), the system **900** determines the position of the source of the signal using the selected receivers **920** and provides a voice capability (e.g., performing voice to text) using one of the plurality of receivers. In a particular embodiment, the receiver used to provide the voice capability may also be used by the processor **902** to determine the location of the source of the signal. In response to predicting that the receiver used for the voice capability is expected to be blocked, the system **900** may de-select the receiver used for the voice capability and select another receiver (e.g., a non-selected receiver) for use in determining the position of the source of the signal. In this embodiment, the receiver used to provide the voice capability may continue to receive power after being de-selected to continue providing the voice capability. In an alternative embodiment, the receiver used to provide the voice capability may be different than the receiver used by the processor **902** to determine the location of the source of the signal. In response to predicting the expected blockage, the processor **902** may select a non-selected receiver for use in determining the location of the source of the signal and may de-select the receiver predicted to be blocked.

In a particular embodiment, the concurrency mode may indicate a concurrency-quadmic mode or a concurrency-normal mode. When the Mode input **944** indicates the concurrency-quadmic mode, the system **900** may determine the location of the source of the signal using four selected receivers when four selected receivers are available (e.g., not being used for other functionality provided by the system **900**, such as voice to text) and predicted to not be blocked. When four selected receivers are not available during concurrency-quadmic mode or the Mode input **944** otherwise indicates the concurrency-normal mode, the system **900** may determine the location of the source of the signal using three selected receivers.

The BDM operation input **946** indicates a receiver power mode. For example, a first BDM operation input may indicate that only selected receivers are to receiver power (e.g., the BDM operation input value **1018**) and a second BDM operation input may indicate that all receivers are to receiver power (e.g., the BDM operation input value **1020**). When the BDM input **946** is the first BDM operation input, the processor **902** may cause the system **900** to cease providing power to a particular selected receiver in response to de-selecting the particular selected receiver. When the BDM operation input **946** is the second BDM operation input, the processor **902** may cause the system **900** to continue to provide power to each of the plurality of receivers after de-selecting the particular receiver.

The configuration input **948** (not shown in FIG. **10**) indicates a current receiver configuration. For example, the system **900** may store configuration information similar to Table 1 at a memory (not shown) of the system **900**. The configuration information may be used by the processor **902** to determine which non-selected receiver should be selected in response to predicting an expected blockage of a selected receiver, as described with reference to FIG. **1**.

An output of the prediction algorithm **912** may cause the processor **902** to modify the current configuration **920** of the receivers from a first configuration (i.e., the configuration indicated by the configuration input **948**) to a second configuration. For example, at a second time subsequent to the first time, the processor **902** may modify the configuration of the receivers to a next configuration. As shown in FIG. **9**, when the selected receivers are configured according to the next configuration **930**, the receiver n+3 is a selected receiver and the receiver n is a non-selected receiver. The processor **902** may store information **914** associated with the next configuration at a memory of the processor or at another memory (not shown) of the system **900** and may send a control signal **960** to the receivers. In a particular embodiment, the control signal **960** may cause the receiver n+3 to listen for the signal (e.g., the ultrasound signal) and to generate an output via the BDM **910** for use by the processor **902** in determining the location of the source of the signal. The control signal **960** may cause the receiver n to stop listening for the signal and may cause the BDM **904** to stop generating an output. In a particular embodiment, the control signal **960** may cause the system **900** to provide power to the receiver n+3 and cause the system **900** to stop providing power to the receiver n.

Referring to FIG. **11**, a particular embodiment of a method **1100** for updating a receiver configuration using a prediction algorithm is shown. The method **1100** includes, at **1102**, initiating a plurality of receivers of a device (e.g., the device **100** of FIG. **1**) according to a default configuration, such as one of the configurations described with reference to FIG. **1** and with reference to Table 1. At **1104**, the method **1100** includes receiving a signal (e.g., an ultrasound signal) at selected receivers (e.g., the receivers in the first receiver set). At **1106**, the method **1100** includes providing signal data associated with the signal received at each of the selected receivers to blockage detection mechanisms (BDMs) coupled to each of the selected receivers.

Each of the BDMs may include a delay locked loop (DLL) or a phase locked loop (PLL). At **1108**, the method **1100** includes determining, at each of the BDMs, an output at one of the DLL or the PLL. When the BDMs include DLLs, the output may be a discriminator output as described with reference to FIG. **1**. When the BDMs include PLLs, the output may be a phase output as described with reference to FIG. **1**. At **1112**, the method **1100** includes determining whether the output of each of the BDMs is less than an output threshold. The output threshold may correspond to a predetermined output value that indicates whether a receiver coupled to the BDM is at least partially blocked. For example, when the determination indicates that the output of a particular BDM is less than the output threshold, a particular receiver coupled to the particular BDM may not be at least partially blocked. When the determination indicates that the output of the particular BDM is greater than the output threshold, the particular receiver coupled to the particular BDM may be at least partially blocked.

At **1110**, the method **1100** includes determining, at each of the BDMs, a signal to noise ratio (SNR) value associated with the signal received at each of the receivers. In a particular embodiment, the SNR value may be determined based on the signal data received at the BDMs from the receivers. In another particular embodiment, the SNR value may be determined based on the output of the DLL or the PLL. In this particular embodiment, the method **1100** may include, at **1111**, receiving the output of the DLL or the PLL. At **1114**, the method **1100** includes determining whether the SNR value is less than a SNR threshold. The SNR threshold may correspond to a predetermined SNR value that indicates whether a receiver coupled to the BDM is at least partially blocked. For example, when the determination indicates that the SNR value of a particular BDM is greater than the SNR threshold, a particular receiver coupled to the particular BDM may not be at least partially blocked. When the determination indicates that the SNR value of the particular BDM is less than the SNR threshold, the particular receiver coupled to the particular BDM may be at least partially blocked.

At **1116**, the method **1100** includes receiving the output (i.e., the discriminator output of the DLL or the phase output of the PLL) and the SNR value. At **1118**, the method **1100** includes determining whether to de-select a particular selected receiver and determining whether to select a particular non-selected receiver based on a prediction algorithm. In a particular embodiment, the prediction algorithm may be the prediction algorithm **912** of FIG. **9** and may receive inputs **1150**. The inputs **1150** may correspond to the inputs **942-950** of FIG. **9**. In response to a prediction that at least one selected receiver is expected to be at least partially blocked, the prediction algorithm may determine whether to select a non-selected receiver(s) and whether to de-select the at least one selected receiver that is expected to be at least partially blocked. At **1122**, the method **1100** includes de-selecting the at least one selected receiver that is expected to be at least partially blocked, and, at **1124**, the method **1100** includes selecting the non-selected receiver(s). At **1126**, the method **1100** includes updating the receiver configuration. In a particular embodiment, updating the receiver configuration may include causing the device to provide power to the non-selected receiver(s) that are selected by the prediction algorithm and causing the device to stop providing power to the selected receivers that are de-selected by the prediction algorithm. In an embodiment, updating the receiver configuration may include storing information indicating a current receiver configuration at a memory of the device, as described with reference to FIG. **9**.

In a particular embodiment, the method **1100** may include, at **1120**, determining whether a count value exceeds a threshold_blocked count value. The count value may indicate a number of sequential BDM outputs (e.g., the output of step **1116**) indicating an expected blockage of a particular receiver. When the count value exceeds the threshold_blocked count value, the prediction algorithm may be enabled. By enabling the prediction algorithm when count_value exceeds a threshold_blocked count value (e.g., when a selected receiver is expected or predicted to be blocked a threshold number of times), a device implementing the method **1100** may avoid oscillating or toggling between selected and non-selected receivers. In a particular embodiment, determining whether the count value exceeds the threshold_blocked count value may be included within the prediction algorithm.

In a particular embodiment, the default configuration may indicate that a first set of receivers of the plurality of receivers are selected receivers (i.e., used by a processor of the device for determining a location of a source of a signal) and that a second set of receivers are non-selected receivers (i.e., not used by the processor for location determinations). In another particular embodiment, each of the plurality of receivers may be initialized as selected receivers, and, in response to receiving signals at each of the plurality of receivers, the processor may determine which of the selected receivers to de-select. For example, the processor may execute a prediction algorithm, such as the prediction algorithm described with reference to FIG. **9**, to determine whether to de-select one or more of the plurality of receivers.

Referring to FIG. **12**, a portion of a lookup table **1200** for use with a prediction algorithm is shown. The lookup table **1200** may be stored at a memory of a device, such as the device **900** of FIG. **9**. The device may include a plurality of receivers. The plurality of receivers including multiple selected receivers (e.g., a first set of receivers) and at least one non-selected receiver (e.g., a second set of receivers). As shown in FIG. **12**, the lookup table **1200** includes a first column **1202**, a second column **1204**, a third column **1206**, a fourth column **1208**, a fifth column **1210**, a sixth column **1212**, a seventh column **1214**, an eighth column **1216**, a ninth column **1218**, a tenth column **1220**, and an eleventh column **1222**. The device may use the lookup table **1200** in conjunction with a prediction algorithm (e.g., the prediction algorithm **912**) to determine which non-selected receiver to select in response to predicting an expected blockage of a particular selected receiver. In a particular embodiment, the prediction algorithm may query the lookup table based on one or more of the inputs **942-950** and, in response to the query, receive a portion of the lookup table **1200** relevant to the configuration of the inputs **942-950**.

For example, as shown in FIG. **12**, the prediction algorithm may receive inputs (e.g., the inputs **942-950**) indicating a Use Case of the device is a Pen use case (i.e., the Use Case input **942** is Pen), a Mode of the device is a Normal mode (i.e., the Mode input **944** is Normal), a BDM Operation of the device indicates that only selected receivers are to receive power (i.e., the BDM Operation input **946** is Only Selected Receivers Powered), a receiver configuration is receiver configuration **1** (i.e., the Configuration input is 1), and a BDM Type to be used by the prediction algorithm is a BDM configured to generate an SNR value (i.e., the BDM Type input **950** is SNR). The prediction algorithm may query the lookup table **1200** based on the inputs and receive the portion of the lookup table **1200** shown in FIG. **12**. To illustrate, the Use Case associated with the portion of the lookup table **1220** shown in FIG. **12** is the Pen Use Case (e.g., the first column **1202** is Pen), the Mode associated with the portion of the lookup table **1220** shown in FIG. **12** is the Normal Mode, the BDM Operation associated with the portion of the lookup table **1220** shown in FIG. **12** is Only Selected Receivers Powered, and the BDM Type associated with the portion of the lookup table **1220** shown in FIG. **12** is SNR.

The prediction algorithm may use the information included in the portion of the lookup table **1200** to select a particular non-selected receiver. To illustrate, each of the columns **1208**, **1210**, **1212**, **1214**, **1216** correspond to one of the plurality of receivers and may indicate whether the corresponding receiver is selected (e.g., a value of 1) or non-selected (e.g., a value of 0). The portion of the lookup table **1200** shown in FIG. **12** indicates that when the receiver configuration of the device is the receiver configuration **1**, the selected receivers include RCVR**1**, RCVR**2**, and RCVR**3** and the non-selected receivers include RCVR**4** and RCVR**5**. Assuming the particular selected receiver that the prediction algorithm predicted as expected to blocked is the RCVR**1**, the prediction algorithm may access the first row of the lookup table **1200** (i.e., the row associated with the receiver configuration **1**) and, based on the tenth column **1220**, identify the RCVR**4** and the RCVR**5** as non-selected receivers.

The prediction algorithm may determine a next receiver configuration based on the information value of the tenth column **1220** corresponding to the receiver configuration **1**. For example, because the RCVR**1** is expected to be blocked and one of the non-selected receivers (e.g., RCVR**4** or RCVR**5**) is to be selected, the prediction algorithm may determine that the next receiver configuration is to be the receiver configuration **6** or the receiver configuration **7**. The prediction algorithm may predict whether the RCVR**4** and the RCVR**5** are expected to be blocked as described with reference to

FIGS. **1**, **5**A-7D, and **9-11**, and as described further with reference to FIGS. **13-18**. When the prediction algorithm predicts an expected blockage of the RCVR**4** and predicts that the RCVR**5** is not expected to be blocked, the prediction algorithm may determine that the next receiver configuration is the receiver configuration **7** (i.e., RCVRs **1** and **4** are non-selected receivers and RCVRs **2**, **3**, and **5** are selected receivers). When the prediction algorithm predicts an expected blockage of the RCVR**5** and predicts that the RCVR**4** is not expected to be blocked, the prediction algorithm may determine that the next receiver configuration is the receiver configuration **6** (i.e., RCVRs **1** and **5** are non-selected receivers and RCVRs **2**, **3**, and **4** are selected receivers).

The prediction algorithm, in response to determining the next receiver configuration, may store the next receiver configuration as a current receiver configuration at a memory of the device and may cause the device to modify the configuration of the receivers via one or more control signals (e.g., the control signals **960**). The control signals may cause the device to de-select the RCVR**1** and select either the RCVR**4** or the RCVR**5**. Based on the BDM Operation input, the control signals may cause the device to stop providing power to the RCVR**1** and to provide power to either the RCVR**4** or the RCVR**5** (i.e., when the BDM Operation input **946** indicates only selected receivers powered). Methods of determining which non-selected receiver to select are described further with reference to FIGS. **13-18**.

Referring to FIG. **13**, a flowchart of a method **1300** of selecting a non-selected receiver in response to predicting an expected blockage of a selected receiver is shown. In a particular embodiment, the method **1300** may be performed by a processor during execution of a prediction algorithm (e.g., the prediction algorithm **912**). At **1302**, the method **1300** includes receiving signals at a first non-selected receiver and a second non-selected receiver. In a particular embodiment, the first non-selected receiver may be the RCVR**4** described with reference to FIG. **12** and the second non-selected receiver may be the RCVR**5** described with reference to FIG. **12**. The first non-selected receiver may generate first signal data **1320** and the second non-selected receiver may generate second signal data **1330**. The first signal data **1320** and the second signal data **1330** may be descriptive of the signals received at the first non-selected receiver and the second non-selected receiver, respectively.

At **1304**, the method **1300** includes calculating a first signal to noise ratio (SNR) value **1322** based on the first signal data **1320**. At **1306**, the method **1300** includes calculating a second SNR value **1332** based on the second signal data **1330**. The first SNR value **1322** may correspond to a signal to noise ratio associated with the signals received at the first non-selected receiver, and the second SNR value **1332** may correspond to a signal to noise ratio associated with the signals received at the second non-selected receiver. At **1308**, the method **1300** includes determining whether the first SNR value **1322** is greater than the second SNR value **1332**. When the first SNR value **1322** is greater than the second SNR value **1332**, the method **1300** includes, at **1310**, selecting the first non-selected receiver. When the second SNR value **1332** is greater than the first SNR value **1322**, the method **1300** includes, at **1312**, selecting the second non-selected receiver. In a particular embodiment, selecting a non-selected receiver (e.g., the first non-selected receiver) may further include de-selecting the other non-selected receiver (e.g., the second non-selected receiver). In a particular embodiment, selecting the non-selected receiver may further include de-selecting a selected receiver that was predicted to be blocked. At **1314**, the method **1300** includes updating the receiver configuration. In an embodiment, updating the receiver configuration may include generating control signals (e.g., the control signals **960**) and storing the receiver configuration (e.g., the receiver configuration **914**) at a memory, as described with reference to FIG. **9**.

Referring to FIG. **14**, a flowchart of another method **1400** of selecting a non-selected receiver in response to predicting an expected blockage of a selected receiver is shown. In a particular embodiment, the method **1400** may be performed by a processor during execution of a prediction algorithm (e.g., the prediction algorithm **912**). At **1402**, the method **1400** includes receiving signals at a first non-selected receiver and a second non-selected receiver. In a particular embodiment, the first non-selected receiver may be the RCVR**4** described with reference to FIG. **12** and the second non-selected receiver may be the RCVR**5** described with reference to FIG. **12**. The first non-selected receiver may generate first signal data **1420**, and the second non-selected receiver may generate second signal data **1430**. The first signal data **1420** and the second signal data **1430** may be descriptive of the signals received at the first non-selected receiver and the second non-selected receiver, respectively.

At **1404**, the method **1400** includes calculating a first output **1422** based on the first signal data **1420**. At **1406**, the method **1400** includes calculating a second output **1432** based on the second signal data **1430**. In a particular embodiment, the first output **1422** may correspond to a first discriminator output of a first delay locked loop (DLL) of a blockage detection mechanism (BDM) coupled to the first non-selected receiver, and the second output **1432** may correspond a second discriminator output of a second DLL of a second BDM coupled to the second non-selected receiver. In a particular embodiment, the first output **1422** may correspond to a first phase output of a first phase locked loop (PLL) of a blockage detection mechanism (BDM) coupled to the first non-selected receiver, and the second output **1432** may correspond a second phase output of a second PLL of a second BDM coupled to the second non-selected receiver. At **1408**, the method **1400** includes determining whether the first output **1422** is less than the second output **1432**. When the first output **1422** is less than the second output **1432**, the method **1400** includes, at **1410**, selecting the first non-selected receiver. When the second output **1432** is less than the first output **1422**, the method **1400** includes, at **1412**, selecting the second non-selected receiver. In a particular embodiment, selecting a non-selected receiver (e.g., the first non-selected receiver) may further include de-selecting the other non-selected receiver (e.g., the second non-selected receiver). In a particular embodiment, selecting the non-selected receiver may further include de-selecting the selected receiver that was predicted to be blocked. At **1414**, the method **1400** includes updating the receiver configuration.

Referring to FIG. **15**, a flowchart of another method **1500** of selecting a non-selected receiver in response to predicting an expected blockage of a selected receiver is shown. In a particular embodiment, the method **1500** may be performed by a processor during execution of a prediction algorithm (e.g., the prediction algorithm **912**). At **1502**, the method **1500** includes receiving signals at a first non-selected receiver and a second non-selected receiver. In a particular embodiment, the first non-selected receiver may be the RCVR**4** described with reference to FIG. **12** and the second non-selected receiver may be the RCVR**5** described with reference to FIG. **12**. The first non-selected receiver may generate first signal data **1520**, and the second non-selected receiver may generate second signal data **1530**. The first signal data **1520** and the second signal data **1530** may be descriptive of the signals received at the first non-selected receiver and the second non-selected receiver, respectively.

At **1504**, the method **1500** includes calculating a SNR value **1522** based on the first signal data **1520**. At **1506**, the method **1500** includes calculating an output **1532** based on the second signal data **1530**. In a particular embodiment, the SNR value **1522** may correspond to a signal to noise ratio associated with the signals received at the first non-selected receiver, and the second output **1532** may correspond a discriminator output of a delay locked loop (DLL) or a phase output of a phase locked loop (PLL) of a BDM coupled to the second non-selected receiver. At **1508**, the method **1500** includes determining whether the SNR value **1522** is less than an SNR threshold (e.g., the SNR threshold described with reference to FIG. **11**). At **1510**, the method **1500** includes determining whether the output (i.e., the discriminator output or the phase output) is less than an output threshold (e.g., the output threshold described with reference to FIG. **11**). In a particular embodiment, the prediction algorithm may determine whether the SNR value **1522** is greater than the SNR threshold and whether the output is less than the output threshold. At **1512**, the method **1500** includes determining, based on an output **1524** of the comparison of the SNR value **1522** to the SNR threshold, and based on an output **1534** of the comparison of the output **1532** to the output threshold, a selected receiver for use in determining a location of a source of the signals.

When the output **1524** indicates that the SNR value **1522** is greater than the SNR threshold and the output **1534** indicates that the output **1532** is greater than the output threshold, the method **1500** includes, at **1514**, selecting the first non-selected receiver. When the output **1524** indicates that the SNR value **1522** is less than the SNR threshold and the output **1534** indicates that the output **1532** is less than the output threshold, the method **1500** includes, at **1516**, selecting the second non-selected receiver. When the output **1524** indicates that the SNR value **1522** is less than the SNR threshold and the output **1534** indicates that the output **1532** is greater than the output threshold, determining which of the non-selected receivers is to be selected may be determined based on other factors. For example, when outputs of each of the BDMS coupled to non-selected receivers do not satisfy a threshold (e.g., an SNR value is less than the SNR threshold or a discriminator output or phase output is greater than the output threshold), the particular non-selected receiver to be selected for use in determining the location of the source of the signals may be determined based on a predetermined order or based on a location of the particular non-selected receiver relative to the selected receiver that is predicted to be blocked. In a particular embodiment, selecting a non-selected receiver (e.g., the first non-selected receiver) may further include de-selecting the other non-selected receiver (e.g., the second non-selected receiver). In a particular embodiment, selecting the non-selected receiver may further include de-selecting the selected receiver that was predicted to be blocked. At **1518**, the method **1500** includes updating a receiver configuration. In an embodiment, updating the receiver configuration may include generating control signals (e.g., the control signals **960**) and storing the receiver configuration (e.g., the receiver configuration **914**) at a memory, as described with reference to FIG. **9**.

Referring to FIG. **16**A, a flowchart of a method **1600** of providing power to selected receivers based on an output of a blockage detection mechanism (BDM) including a delay locked loop (DLL) or a phase locked loop (PLL) is shown. The method **1600** includes, at **1602**, initializing a plurality of receivers to a default configuration. In a particular embodiment, the default configuration may identify a first set of the plurality of receivers as selected receivers and a second set of the plurality of receivers as non-selected receivers. In another particular embodiment, the default configuration may identify each of the plurality of receivers as selected receivers and a set of non-selected receivers may subsequently be determined based on an output of a BDM (e.g., a discriminator output of a DLL, a phase output of a PLL, or a SNR value). In an embodiment, the default configuration may be determined based on a lookup table (e.g., the Table 1 described with reference to FIG. **1**).

At **1604**, the method **1600** includes receiving a signal (e.g., an ultrasound signal) at a selected receiver. At **1606**, the method **1600** includes calculating, at a BDM coupled to the selected receiver, one of a discriminator output and a phase output. In a particular embodiment, the BDM may include a DLL, a PLL, or both. The DLL may be configured to calculate the discriminator output based on the signal received at the selected receiver. The PLL may be configured to calculate the phase output based on the signal received at the selected receiver. At **1608**, the method **1600** includes determining whether the output of the BDM is less than an output threshold. In a particular embodiment, the output threshold corresponds to a predetermined value that indicates the receiver coupled to the BDM is not blocked (or not partially blocked). In another particular embodiment, the output threshold corresponds to a predetermined value that indicates the receiver coupled to the BDM is at least partially blocked.

When the output (e.g., the discriminator output or the phase output) of the BDM is less than the output threshold (i.e., the receiver coupled to the BDM is not blocked), the method **1600** may include, at **1620**, monitoring the output of the BDM. In an embodiment, monitoring the output of the BDM may include calculating a second output of the BDM. In another embodiment, monitoring the output of the BDM may include determining whether a time period has elapsed and, when the time period has elapsed, calculating the second output of the BDM. When the output of the BDM exceeds or is equal to the output threshold (i.e., the receiver is blocked), the method **1600** includes, at **1610**, executing a prediction algorithm (e.g., the prediction algorithm **912** of FIG. **9**). In a particular embodiment, the prediction algorithm may predict whether a non-selected receiver is expected to be blocked, as described with reference to FIGS. **1**, **5**A-**7**D, and **9**-**15**.

At **1612**, the method **1600** includes turning off (i.e., ceasing to provide power to) the selected receiver that was predicted to be blocked based on the output (i.e., the output calculated at **1606**) of the BDM and, at **1614**, turning on (i.e., providing power to) the non-selected receiver identified based on the prediction algorithm, as described with reference to FIGS. **13**-**15**. At **1616**, the method **1600** includes updating the receiver configuration. In an embodiment, updating the receiver configuration may include generating control signals (e.g., the control signals **960**) and storing the receiver configuration (e.g., the receiver configuration **914**) at a memory, as described with reference to FIG. **9**.

Referring to FIG. **16**B, a flowchart of a method **1650** of providing power to selected receivers based on an output of a blockage detection mechanism (BDM) configured to generate a signal to noise ratio (SNR) value is shown. The method **1650** includes, at **1652**, initializing a plurality of receivers to a default configuration. In a particular embodiment, the default configuration may identify a first set of the plurality of receivers as selected receivers and a second set of the plurality of receivers as non-selected receivers. In another particular embodiment, the default configuration may identify each of the plurality of receivers as selected receivers and a set of non-selected receivers may subsequently be determined based on an output of a BDM (e.g., a discriminator output of a DLL, a phase output of a PLL, or a SNR value). In an embodiment, the default configuration may be determined based on a lookup table (e.g., the Table 1 described with reference to FIG. **1**).

At **1654**, the method **1650** includes receiving a signal (e.g., an ultrasound signal) at a selected receiver. At **1656**, the method **1650** includes calculating, at a BDM coupled to the selected receiver, an SNR value. At **1658**, the method **1650** includes determining whether the output of the BDM (e.g., the SNR value) is greater than an SNR threshold. In a particular embodiment, the SNR threshold corresponds to a predetermined SNR value that indicates the receiver coupled to the BDM is not blocked (or not partially blocked). In another particular embodiment, the SNR threshold corresponds to a predetermined SNR value that indicates the receiver coupled to the BDM is at least partially blocked.

When the SNR value is greater than the SNR threshold (i.e., the receiver coupled to the BDM is not blocked), the method **1650** may include, at **1670**, monitoring the SNR value output by the BDM. In an embodiment, monitoring the SNR value may include calculating a second SNR value. In another embodiment, monitoring the SNR value output by the BDM may include determining whether a time period has elapsed and, when the time period has elapsed, calculating the second SNR value. When the SNR value is less than or is equal to the SNR threshold (i.e., the receiver is blocked), the method **1650** includes, at **1610**, executing a prediction algorithm (e.g., the prediction algorithm **912**). In a particular embodiment, the prediction algorithm may predict whether a non-selected receiver is expected to be blocked, as described with reference to FIGS. **13-15**.

At **1662**, the method **1650** includes turning off (i.e., ceasing to provide power to) the selected receiver that was predicted to be blocked based on the SNR value (i.e., the SNR value calculated at **1656**) and, at **1664**, turning on (i.e., providing power to) to the non-selected receiver identified based on the prediction algorithm, as described with reference to FIGS. **13-15**. At **1666**, the method **1650** includes updating the receiver configuration. In an embodiment, updating the receiver configuration may include generating control signals (e.g., the control signals **960**) and storing the receiver configuration (e.g., the receiver configuration **914**) at a memory, as described with reference to FIG. **9**.

Referring to FIG. **17**, a flowchart of a method **1700** of predicting an expected blockage of a selected receiver is shown. The method **1700** includes, at **1710**, determining a tracing direction of a source of a signal. The method **1700** may be performed by a processor (e.g., the processor **102** of FIG. **1**) to determine a tracing direction (e.g., a direction of travel or expected direction of travel) of a transmitter (e.g., the transmitter **204** of FIG. **2**). The tracing direction may be determined based on information received at the processor. For example, information associated with a current location of the source of the signal may be received at the processor from a location history buffer **1702**. Additionally, or in the alternative, the processor may receive information associated with one or more previous locations of the source of the signal from the location history buffer **1702**.

In an embodiment, the one or more previous locations may be used to determine whether a user of the device is right or left handed. For example, if the one or more previous locations indicate that the source of the signal is predominately blocked from the receivers to the right of the source location as the source moves from left to right, the user may be right handed. If the one or more previous locations indicate that the source of the signal is predominately blocked from the receivers to the left of the source location as the source moves from left to right, the user may be left handed. The processor may receive a gesture algorithm or output of the gesture algorithm from a gesture algorithm unit **1706**. The gesture algorithm, or an output of the gesture algorithm, may be executed, at **1710**, to determine the tracing direction of the source of the signal based on the current location of the source of the signal and the one or more previous locations of the source of the signal. Additionally, coordinates of receivers **1704** (e.g., the receivers **112-124**) may be received by the processor.

At **1704**, the method **1700** includes determining coordinates associated with non-selected receivers. The coordinates may be provided to the gesture algorithm **1706** for use in determining the tracing direction. In a particular embodiment, the tracing direction information **1750** may include the coordinates associated with the non-selected receivers, an indication of whether the user is left handed or right handed, the pen switch state, the selected receiver that is expected to be blocked, or any combination thereof. For example, if the user is right handed and the determined tracing direction is left to right, the prediction algorithm may use a table-look-up to identify a non-selected receiver with a coordinate position to the left of the current location of the source of the signal. A non-selected receiver with a coordinate position to the left of the location of the source of the signal may be less likely to be blocked in the future because the information received from the history buffer indicates that the user is right handed and that selected receivers to the right of the source of the signal are more likely to be blocked when the tracing direction is left to right. As a result of the table-look-up, a next receiver configuration (e.g., CONFIG-**2** of Table 1) may be identified. In a particular embodiment, the prediction algorithm may determine the tracing direction and may generate the tracing direction information **1750**.

When the source of the signal is a stylus pen, such as the stylus pen **202** of FIG. **2**, the method **1700** may also include receiving a pen switch state **1708**. The pen switch state **1708** may indicate whether the stylus pen is being used to input information. For example, the pen switch state **1708** may have a first value when a nib of the stylus pen is touching or nearly touching a writing surface (e.g., the display **322** of FIG. **3**A) and may have a second value when the nib of the pen is not touching or nearly touching the writing surface.

The method **1700** includes, at **1712**, executing a prediction algorithm (e.g., the prediction algorithm **912** of FIG. **9**) to identify or more non-selected receivers that may be selected in response to predicting an expected blockage of a selected receiver. As shown in FIG. **17**, the prediction algorithm may receive tracing direction information **1750** that indicates the tracing direction determined at **1710** and signal data **1760** that includes an output (i.e., a discriminator output of a DLL, a phase output of a PLL, an SNR value, or a combination thereof) of each BDM coupled to a selected receiver. The prediction algorithm may also receive input data **1770**. In a particular embodiment, the input data **1770** corresponds to one or more the inputs **942-950** described with reference to FIG. **9**. In a particular embodiment, the input data **1770** may include count enable control data. The count enable control data may indicate whether the prediction algorithm is to determine whether to predict an expected blockage of a particular receiver, or to select a non-selected receiver when a count value exceeds a threshold_blocked count value, as described with reference to FIG. **9**.

In a particular embodiment, the input data **1770** may include a Use Case input (e.g., the Use Case input **942**) indicating that the device is operating in a Pen Mode and is interacting with an external device (e.g., the stylus pen). The prediction algorithm may, based on the use case input, use the tracing direction information **1750** when predicting an expected blockage of a selected receiver and may also use the tracing direction information **1750** when determining which non-selected receiver should be selected in response to predicting an expected blockage of a selected receiver. When the Use Case input does not indicate the device is operating in the Pen Mode, the prediction algorithm may not use the tracing direction information **1750**.

In another particular embodiment, the input data **1770** may include a Use Case input (e.g., the Use Case input **942** of FIG. **9**) indicating that the device is operating in a Tablet Mode and is interacting with another device (e.g., a tablet device). For example, the device may, based on signals received at the selected receivers, determine a direction of and/or distance to the other device relative to the device. The prediction algorithm may, based on the use case input indicating that the device is operating in the Tablet mode, use the gesture algorithm **1706** and the tracing information **1750** to predict a direction of travel of the other device. The prediction algorithm may predict an expected blockage of a selected receiver based at least in part on the direction of travel of the other device and may also use the direction of travel of the other device when determining which non-selected receiver should be selected in response to predicting an expected blockage of a selected receiver. For example, when the other device is moving left to right relative to the device, the prediction algorithm may determine that a non-selected receiver located on the left side of the device, or a receiver located closer to the other device (e.g., based on the distance and direction), is less likely to be blocked and select the non-selected receiver.

In a particular embodiment, the prediction algorithm may validate the next receiver configuration. Validating the next receiver configuration may include determining whether one or more non-selected receivers to be selected are expected to be blocked. If the next receiver configuration is invalid (e.g., one or more receivers identified as selected receivers in the next receiver configuration are predicted to be blocked), the method **1700** includes, at **1712**, performing the table-look-up again. If the next receiver configuration is valid (e.g., the receivers identified as selected receivers in the next receiver configuration are not predicted to be blocked), or if validation is skipped, the method may include, at **1716**, turning off one or more selected receivers identified in the next receiver configuration as non-selected receivers (e.g., ceasing to provide power to selected receivers predicted to be blocked). The method may include, at **1718**, turning on one or more non-selected receivers identified in the next receiver configuration as selected receivers (e.g., providing power to selected receivers). By dynamically powering the selected receivers on and the de-selected receivers off using the method **1700**, a device is able to maintain a reduced number of selected receivers for use in determining a location of the source of the signal, thus reducing power consumption.

Referring to FIG. **18**, an embodiment of a system **1800** configured to predict an expected blockage of a selected receiver is shown. The system **1800** includes receivers **1802-1806**, a prediction engine **1808**, a mode switch **1810**, a receiver processing unit **1812**, an ultrasound transmitter **1816**, and an audio speaker **1814**. As shown in FIG. **18**, each of the receivers **1802-1806** is coupled to the prediction engine **1808**. In an embodiment, the receivers **1802-1806** may be coupled to BDMs (not shown) and an output of the BDMs may be provided to the prediction engine **1808**. The prediction engine **1808** may predict an expected blockage of a signal path between a source of a signal and each of the receivers **1802-1806**. For example, the prediction engine **1808** may predict the expected blockage of the signal path by executing a prediction algorithm, such as the prediction algorithm **912** described with reference to FIG. **9**. In response to predicting an expected blockage, the prediction engine **1808** may identify a non-selected receiver (not shown) that is to be selected. The prediction engine **1808** may transmit a signal to the mode switch **1810** that identifies the non-selected receiver that is to be selected, and the mode switch **1810** may select (e.g., activate) the identified receiver. The mode switch **1810** may de-select (e.g., deactivate) the receiver that is predicted to be blocked. The receiver processing unit **1812** may perform location detection (e.g., 2D or 3D location detection) as described with reference to FIGS. **1-8**. For example, in an embodiment, the receiver processing unit **1812** may determine the location of the source of the signal using a time difference of arrival (TDOA).

In a particular embodiment, when a user is using the system **1800** to perform multiple activities simultaneously or concurrently (e.g., using a receiver to input audio data, using multiple receivers for stylus pen location tracking and listening to audio output by the system **1800**), the system **1800** may allocate resources of the system **1800**, such as the audio speakers **1814** and the ultrasound transmitter **1816**, to perform the multiple activities. For example, the ultrasound transmitter **1816** may be used to send ultrasound signals to detect blocked microphone channels so that the system **1800** uses an unblocked microphone or other receiver to receive the audio input from the user. The unblocked microphones or other receivers can also be used to control a speaker path signal, such as a signal level, a pattern, a signal path (in a multiple speaker scenario), etc., for noise cancellation or other purposes.

Referring to FIG. **19**, an illustrative example of a circuit for implementing a delay locked loop (DLL) for use in predicting an expected blockage of a signal path of a signal is shown and generally designated **1900**. The DLL **1900** of FIG. **19** may be used as a blockage detection mechanism (BDM). The DLL **1900** may receive a signal s(t). The signal s(t) may be provided to a discriminator by a receiver (e.g., one of the receivers **112-124** of FIG. **1**). The signal s(t) is provided to processing blocks **1902**. A first processing block **1902** may provide a first processed signal s(t) to a discriminator **1904** via a path E. A second processing block **1902** may provide a second processed signal s(t) to the discriminator **1904** via a path P. A third processing block **1902** may provide a third processed signal s(t) to the discriminator **1904** via a path L. The discriminator **1904** may generate an output Δt. The output Δt of the discriminator **1904** may be provided to a processor (e.g., the processor **102** of FIG. **1**). The processor may predict an expected blockage of a signal path between a source of the signal s(t) and the selected receiver that provides the signal to the DLL based on the output Δt. Thus, the output Δt generated by the DLL of FIG. **19** may be used by a processor (e.g., the processor **102**) to predict an expected blockage of a selected receiver. A device may select and de-select receivers based on the predicted expected blockage, thus consuming less power than if all receivers were kept selected (i.e., actively being used to process signals).

Referring to FIG. **20**, an illustrative example of an output of the DLL of FIG. **19** is shown. As shown in FIG. **20**, a correct offset occurs when the output of the discriminator **1904** is zero. A discriminator output of zero may indicate that a selected receiver is receiving a signal from a signal source via a signal path that has line of sight between the signal source and the selected receiver (i.e., the signal path is not blocked).

Referring to FIG. **21**, another illustrative example of an output of the DLL of FIG. **19** is shown. As shown in FIG. **21**, a correct offset occurs when the output of the discriminator is zero. In FIG. **21**, the discriminator output is offset to the right of the correct offset of zero. A non-zero discriminator output may indicate that a selected receiver is receiving a signal from a signal source via a signal path that is at least partially blocked. For example, the non-zero discriminator output may indicate that the signal path is partially blocked as described with reference to FIG. **6**B or that the signal path is completely blocked as described with reference to FIG. **6**C.

Referring to FIG. **22**, a block diagram of an embodiment of a system **2200** is shown. The system **2200** may be used to synchronize a system clock signal (e.g., the clock signal **150** of FIG. **1**) with a clock signal associated with a source of a received signal (e.g., the clock signal **206** of FIG. **2**). As shown in FIG. **22**, the system **2200** includes multiple receivers (e.g., the receiver **2202**-receiver (N) **2206**). Each of the receivers **2202**-**2206** may be coupled to a blockage detection mechanism (BDM). For example, the receiver **2202** is coupled to a first BDM **2208**, the receiver **2204** is coupled to a second BDM **2210**, and the receiver (N) **2206** is coupled to a BDM **2212**. Each of the BDMs **2208**-**2212** may provide an output (e.g., a discriminator output) to a receiver selection unit **2214** and to a processor **2220**. In an embodiment, only some of the receivers **2202**-**2206** are selected receivers (e.g., a first set of receivers) and only the BDMs that are coupled to the selected receivers provide an output to the receiver selection unit **2214**.

The receiver selection unit **2214** may identify a particular selected receiver of the receivers **2202**-**2206** with a lowest output value (e.g., a lowest discriminator output). As described with reference to FIG. **20**, when a signal path between a source of a signal and a receiver is unobstructed (i.e., a line of sight signal path exists), the output of a DLL is zero or below a threshold. When the signal path between the source of the signal and the receiver is at least partially blocked (i.e., there is not a complete line of sight signal path), the output of a DLL is non-zero or greater than a threshold. The receiver selection unit **2214** may provide the signal corresponding to the received output of the BDM of the particular selected receiver to a receiver system clock **2216**. The receiver system clock **2216** may generate a clock signal **2218** that may be used to synchronize a system clock signal (e.g., the clock signal **150** of FIG. **1**) with a clock signal of the source of the signal (e.g., clock signal **206** of FIG. **2**). The synchronized clock signals may be used to perform time difference of arrival calculations to determine a location of a source of the received signal.

As shown in FIG. **22**, the outputs of the BDMs may be provided to the processor **2220**. The processor **2220** may execute a prediction algorithm **2242** (e.g., the prediction algorithm **912** of FIG. **9**). In response to executing the prediction algorithm **2242**, the processor **2220** may generate an output **2222**. The output **2222** may include a control signal (e.g., the control signal **960**), an updated receiver configuration (e.g., the configuration data **914**), or both.

Referring to FIG. **23**, a block diagram of another embodiment of a system **2300** to synchronize a system clock signal with a clock signal associated with a source of a received signal is shown. As shown in FIG. **23**, the system includes multiple receivers (e.g., receiver **2302**-receiver (N) **2306**). As shown in FIG. **23**, each of the receivers **2302**-**2306** may be coupled to a BDM **2310**. For example, the receiver **2302** is coupled to a BDM **2310**A, the receiver **2304** is coupled to a BDM **2310**B, and the receiver (N) **2306** is coupled to a BDM **2310**C. As shown in FIG. **23**, each of the BDMs **2310** may be coupled to a processor **2340** and to a signal selector **2308**. The signal selector **2308** is configured to receive signal data from each of the receivers **2302**-**2306** and to identify a particular selected receiver of the receivers **2302**-**2306** with a lowest output value. To illustrate, the signal selector may include one or more DLLs or PLLs and may determine an output (e.g., a discriminator output or a phase output) associated with each of the receivers **2302**-**2306**. The signal selector **2308** may identify the particular selected receiver based on the outputs of the receivers and may provide a signal corresponding to the signal received at the particular selected receiver to a delay locked loop (DLL) **2312**. The DLL **2312** may provide an output to a receiver system clock **2314**, and the output may be used by the receiver system clock **2314** to synchronize a system clock signal **2330** (e.g., the clock signal **150** of FIG. **1**) with a clock signal of the source of the signal (e.g., clock signal **206** of FIG. **2**). The synchronized clock signals may be used to perform time difference of arrival calculations to determine a location of a source of the received signal.

As shown in FIG. **23**, the outputs of the BDMs **2310** may be provided to the processor **2340**. The processor **2340** may execute a prediction algorithm **2342** (e.g., the prediction algorithm **912** of FIG. **9**). In response to executing the prediction algorithm **2342**, the processor **2340** may generate an output **2344** including a control signal (e.g., the control signal **960** of FIG. **9**), an updated receiver configuration (e.g., the configuration data **914** of FIG. **9**), or both. In a particular embodiment, the prediction algorithm **2342** may generate the output **2344** based on a comparison of SNR values generated by the BDMs **2310** using a SNR comparator **2343**, as described with reference to FIG. **13**.

Referring to FIG. **24**, a flowchart of another embodiment of a method for predicting an expected blockage of a signal path of a signal is shown. At **2402**, the method **2400** includes placing a device (e.g., the device **102** of FIG. **1**) in a normal (or default) receiver configuration. In an embodiment, the normal receiver configuration may be determined using a look-up table (such as the look-up table **108** of FIG. **1**). When the device is using the normal receiver configuration, the device includes at least one non-selected receiver. At **2404**, the method **2400** includes determining whether a selected receiver of the device is blocked. Determining whether the selected receiver is blocked may include predicting an expected blockage of a signal path between a source of a signal and the selected receiver. If the selected receiver is not blocked, the method **2400** returns to **2402**. If the selected receiver is blocked or an expected blockage is otherwise predicted, the method **2400** includes, at **2406**, determining whether the at least one non-selected receiver is blocked. If the non-selected receiver is not blocked, the method **2400** includes, at **2408**, selecting the non-selected receiver. At **2408**, the method **2400** may further include de-selecting the selected receiver that was predicted to be blocked at **2404**. If the non-selected receiver is determined to be blocked or an expected blockage is otherwise predicted, the method **2400** may include modifying a mode (e.g., switching from a quadmic mode to a normal) of the device, at **2410**.

For example, the device may be the device **102** of FIG. **1**. In the normal receiver configuration, the device may be configured to determine a 3-dimensional (3D) location of the source of the signal. Accordingly, the device may maintain at least four selected receivers (e.g., a first set of receivers) that are able to receive the signal from the source (e.g., receivers that are not blocked). If one of the four selected receivers is determined to be blocked or an expected blockage is otherwise predicted, the device may select a non-selected receiver (e.g., a second set of receivers) in order to maintain a sufficient number of selected receivers to determine the 3D location of the source. If there are no non-blocked non-selected receivers, the device may operate with three selected receivers by modifying the mode of operation of the device. When operating with three selected receivers, the device may determine a 2D location of the source of the signal. Thus, a device implementing the method **2400** may be operable to dynamically switch between determining a 3D location of a signal source and a 2D location of the signal source based on a determination that one or more selected receivers are blocked. By maintaining at least one non-selected receiver, the device consumes less power than if all receivers are selected (i.e., used for determining the location of a source of a signal).

Referring to FIG. **25**, a flowchart of a method **2500** of selecting a non-selected receiver is shown. The method **2500** includes, at **2502**, detecting a signal at a first set of receivers of a plurality of receivers (e.g., the receivers **112-124** of FIG. **1**) of a device (e.g., the device **100** of FIG. **1**). The plurality of receivers includes the first set of receivers and a second set of receivers. The first set of receivers corresponds to selected receivers and the second set of receivers corresponds to non-selected receivers. At **2504**, the method **2500** includes predicting, based on the signal, an expected blockage of a signal path between a source of the signal (e.g., the transmitter **204** of FIG. **2**) and a first selected receiver of the first set of receivers. The method **2500** further includes, at **2506**, selecting a particular receiver of the second set of receivers as a newly selected receiver in response to predicting the expected blockage. In a particular embodiment, two or more non-selected receivers (e.g., two or more receivers of the second set of receivers) may be selected in response to predicting the expected blockage, in response to determining that the source of the signal is located in a particular region, such as in a corner or at an edge of a device that includes the receivers, or both.

Referring to FIG. **26**, a block diagram of a computer system operable to support the various methods, systems, devices, and computer readable media described with respect to FIGS. **1-25** is shown. The device **2600** includes a processor **2664** coupled to a cache memory **2612** and to a memory **2604**. The memory **2604** may store blockage prediction instructions **2606** and a look-up table **2608**. The blockage prediction instructions **2606** may be executable by the processor **2664** to perform a method of predicting expected blockage of one or more active receivers, and in response to predicting the expected blockage, activating one or more inactive receivers.

FIG. **26** also shows a display controller **2626** that is coupled to the processor **2664** and to a display **2628**. A coder/decoder (CODEC) **2634** can also be coupled to the processor **2664**. A speaker **2636** and receivers **2638** can be coupled to the CODEC **2634**.

FIG. **26** also indicates that a wireless controller **2640** can be coupled to the processor **2664** and to a wireless antenna **2642**. In a particular embodiment, the processor **2664**, the display controller **2626**, the memory **2604**, the CODEC **2634**, and the wireless controller **2640** are included in a system-in-package or system-on-chip device **2622**. In a particular embodiment, an input device **2630** and a power supply **2644** are coupled to the system-on-chip device **2622**. Moreover, in a particular embodiment, as illustrated in FIG. **26**, the display **2628**, the input device **2630**, the speaker **2636**, the receivers **2638**, the wireless antenna **2642**, and the power supply **2644** are external to the system-on-chip device **2622**. However, each of the display **2628**, the input device **2630**, the speaker **2636**, the receivers **2638**, the wireless antenna **2642**, and the power supply **2644** can be coupled to a component of the system-on-chip device **2622**, such as an interface or a controller.

It should be noted that although FIG. **26** depicts a wireless communications device, the processor **2664** and the memory **2604** may also be integrated into other electronic devices, such as a set top box, a music player, a video player, an entertainment unit, a navigation device, a personal digital assistant (PDA), a fixed location data unit, or a computer.

In conjunction with the described embodiments, a system is disclosed that is configured to perform receiver switching (e.g., selecting receivers and de-selecting receivers) based on signals received at the system from a signal source. The system may include multiple receiving means for receiving the signals. In an embodiment, the multiple receiving means may correspond to receivers, such as the receivers **110** of FIG. **1** or the receivers **302-314** of FIGS. **3**A-**7**D. In another embodiment, the multiple receiving means may include multiple microphones, as described with reference to FIG. **3**. The multiple receiving means may include a first set of receiving means and a second set of receiving means. The first set of receiving means may correspond to selected receiving means and the second set of receiving means may correspond to non-selected receiving means. The system includes means for predicting, based on a received signal, an expected blockage of a signal path between a source of the received signal and a first receiving means of the first set of receiving means. In a particular embodiment, the means for predicting may be a processor, such as the processor **102** of FIG. **1** or the processor **902** of FIG. **9**. The system includes means for selecting a particular receiving means of the second set of receiving means as a newly selected receiving means in response to predicting the expected blockage. In a particular embodiment, the means for selecting may be a processor, such as the processor **102** of FIG. **1** or the processor **902** of FIG. **9**. In a particular embodiment, the multiple receiving means, the means for predicting, and the means for selecting may collectively or individually be implemented by a field-programmable gate array (FPGA) device, an application-specific integrated circuit (ASIC), a processing unit such as a central processing unit (CPU), a digital signal processor (DSP), a controller, another hardware device, a firmware device, or any combination thereof configured to perform receiver switching based on the received signals.

Those of skill would further appreciate that the various illustrative logical blocks, configurations, modules, circuits, and algorithm steps described in connection with the embodiments disclosed herein may be implemented as electronic hardware, computer software, or combinations of both. Various illustrative components, blocks, configurations, modules, circuits, and steps have been described above generally in terms of their functionality. Whether such functionality is implemented as hardware or software depends upon the particular application and design constraints imposed on the overall system. Skilled artisans may implement the described functionality in varying ways for each particular application, but such implementation decisions should not be interpreted as causing a departure from the scope of the present disclosure.

The steps of a method or algorithm described in connection with the embodiments disclosed herein may be embodied directly in hardware, in a software module executed by a processor, or in a combination of the two. A software module may reside in random access memory (RAM), flash memory, read-only memory (ROM), programmable read-only memory (PROM), erasable programmable read-only memory (EPROM), electrically erasable programmable read-only memory (EEPROM), registers, hard disk, a removable disk, a compact disc read-only memory (CD-ROM), or any other form of storage medium known in the art. An exemplary non-transitory (e.g. tangible) storage medium is coupled to the processor such that the processor can read information from, and write information to, the storage medium. In the alternative, the storage medium may be integral to the processor. The processor and the storage medium may reside in an application-specific integrated circuit (ASIC). The ASIC may reside in a computing device or a user terminal. In the alternative, the processor and the storage medium may reside as discrete components in a computing device or user terminal.

The previous description of the disclosed embodiments is provided to enable a person skilled in the art to make or use the disclosed embodiments. Various modifications to these embodiments will be readily apparent to those skilled in the art, and the principles defined herein may be applied to other embodiments without departing from the scope of the disclosure. Thus, the present disclosure is not intended to be limited to the embodiments shown herein but is to be accorded the widest scope possible consistent with the principles and novel features as defined by the following claims.

What is claimed is:

1. A method comprising:

detecting a signal at a first set of receivers of a plurality of receivers of a device, the plurality of receivers including the first set of receivers and a second set of receivers, wherein the first set of receivers corresponds to selected receivers and wherein the second set of receivers corresponds to non-selected receivers;

predicting, based on the signal, an expected blockage of a signal path between a source of the signal and a first receiver of the first set of receivers; and

selecting a particular receiver of the second set of receivers as a newly selected receiver in response to predicting the expected blockage of the signal path.

2. The method of claim **1**, wherein the source comprises an ultrasound transmitter, and wherein the signal comprises an ultrasound signal.

3. The method of claim **1**, further comprising:

predicting a travel path of the source of the signal in response to predicting the expected blockage of the signal path; and

determining the particular receiver of the second set of receivers based on the predicted travel path of the source of the signal.

4. The method of claim **3**, wherein the particular receiver is selected from a look-up table based on information related to other receivers of the first set of receivers, based on information regarding the predicted travel path, based on information regarding a location of the source, or any combination thereof.

5. The method of claim **1**, wherein the particular receiver of the second set of receivers is selected before the signal path is blocked.

6. The method of claim **1**, wherein the expected blockage is a result of movement of the source of the signal, movement of an object, or any combination thereof.

7. The method of claim **3**, further comprising predicting an expected blockage of the first receiver in response to predicting the expected blockage of the signal path, wherein predicting the expected blockage of the first receiver comprises:

calculating a signal-to-noise ratio (SNR) value associated with the first receiver; and

determining whether the SNR value is less than or equal to an SNR threshold.

8. The method of claim **3**, further comprising predicting an expected blockage of the first receiver in response to predicting the expected blockage of the signal path, wherein predicting the expected blockage of the first receiver comprises:

calculating a phase output of a phase-locked loop (PLL) associated with the first receiver; and

determining whether the phase output is greater than or equal to an output threshold.

9. The method of claim **1**, further comprising de-selecting the first receiver in response to predicting the expected blockage.

10. The method of claim **9**, wherein the first receiver is de-selected before the signal path is blocked.

11. The method of claim **1**, wherein the source is located at a location that is not bounded by the plurality of receivers.

12. The method of claim **1**, wherein the source comprises a pen device including a transmitter that generates the signal.

13. The method of claim **1**, further comprising determining a location of the source of the signal based on a time difference of arrival, at two or more receivers of the first set of receivers, of the signal.

14. The method of claim **13**, further comprising selecting two or more receivers of the second set of receivers in response to predicting the expected blockage and in response to determining that the location of the source is within a particular region.

15. The method of claim **1**, further comprising:

after selecting the particular receiver as the newly selected receiver, determining whether a second signal path between the source and the newly selected receiver is blocked; and

when the second signal path is determined to be blocked, activating another particular receiver of the second set of receivers as a second selected receiver and de-selecting the newly selected receiver.

16. An apparatus comprising:

a plurality of receivers including a first set of receivers and a second set of receivers;

a processor; and

a memory configured to store instructions executable by the processor to:

receive one or more signals from the first set of receivers, wherein the first set of receivers corresponds to selected receivers, and wherein the one or more signals received from the first set of receivers are indicative of acoustic signals detected by the first set of receivers;

predict, based on the one or more signals, an expected blockage of a signal path between a source of the acoustic signals detected by the first set of receivers and a first receiver of the first set of receivers; and

select at least one receiver of the second set of receivers in response to a prediction that the signal path is blocked, wherein the second set of receivers corresponds to non-selected receivers.

17. The apparatus of claim **16**, wherein the source of the acoustic signals comprises a transmitter of a pen configured to write on a surface, and wherein the acoustic signals have a frequency in excess of twenty (20) kiloHertz (kHz).

18. The apparatus of claim **17**, wherein the instructions are further executable by the processor to detect a state of the pen based on at least one of the one or more signals received from the first set of receivers, wherein the pen has a first state when the pen is operational but not writing and a second state with the pen is operational and writing.

19. The apparatus of claim **16**, wherein the plurality of receivers includes at least one microphone configured to detect the acoustic signals, and wherein the acoustic signals are outside a human auditory range.

20. The apparatus of claim 16, wherein the instructions are further executable by the processor to generate a first clock signal based on the one or more signals received from the first set of receivers, and wherein the plurality of receivers are synchronized based on the first clock signal.

21. The apparatus of claim 16, wherein the memory further stores a look-up table, and wherein the instructions are further executable by the processor to select the at least one receiver of the second set of receivers based at least in part on the look-up table.

22. The apparatus of claim 16, wherein the plurality of receivers comprises a plurality of microphones configured to detect the acoustic signals and to generate the one or more signals to enable the processor to estimate a distance and a direction to the source of the acoustic signals based on a time difference of arrival of the acoustic signals at a set of microphones of the plurality of microphones, wherein the set of microphones corresponds to the first set of receivers.

23. The apparatus of claim 16, wherein the plurality of receivers, the processor, and the memory are integrated into one of a mobile communication device, a smart phone, a cellular phone, a laptop computer, a computer, a tablet, a personal digital assistant, a display device, a television, a gaming console, a music player, a radio, a digital video player, a digital video disc (DVD) player, a tuner, a camera, and a navigation device.

24. The apparatus of claim 16, wherein the plurality of receivers includes at least one microphone configured to detect the acoustic signals, and wherein first acoustic signals of the acoustic signals are inside a human auditory range and second acoustic signals of the acoustic signals are outside of the human auditory range.

25. A non-transitory computer-readable medium comprising instructions executable by a processor to cause the processor to perform operations including:

receiving one or more signals from a first set of receivers of a plurality of receivers of a device, the plurality of receivers including the first set of receivers and a second set of receivers, wherein the first set of receivers correspond to selected receivers, wherein the second set of receivers correspond to non-selected receivers, and wherein the one or more signals received from the first set of receivers are indicative of acoustic signals detected by the first set of receivers;

predicting, based on the one or more signals, an expected blockage of a signal path between a source of the acoustic signals and a first receiver of the first set of receivers; and

selecting a particular receiver of the second set of receivers as a newly selected receiver in response to predicting the expected blockage of the signal path.

26. The non-transitory computer-readable medium of claim 25, wherein the plurality of receivers includes at least one microphone.

27. The non-transitory computer-readable medium of claim 25, wherein the plurality of receivers includes at least one microphone configured to detect first acoustic signals of the acoustic signals, the first acoustic signals having a frequency in excess of twenty (20) kiloHertz (kHz), and at least one microphone configured to detect second acoustic signals of the acoustic signals, the second acoustic signals having a frequency between twenty (20) Hertz (Hz) and twenty (20) kHz.

28. The non-transitory computer-readable medium of claim 25, wherein the operations further comprise:

predicting a travel path of the source of the acoustic signals in response to predicting the expected blockage of the signal path; and

selecting the particular receiver of the second set of receivers based on the predicted travel path of the source of the acoustic signals.

29. The non-transitory computer-readable medium of claim 28, wherein the particular receiver is selected from a look-up table based on information related to the first set of receivers, based on information regarding the predicted travel path, based on information regarding a location of the source, or any combination thereof.

30. The non-transitory computer-readable medium of claim 25, wherein the operations further comprise de-selecting the first receiver in response to predicting the expected blockage.

31. An apparatus comprising:

multiple receiving means for receiving one or more signals, the multiple receiving means including a first set of means for detecting acoustic signals and a second set of means for detecting the acoustic signals, wherein the first set of means for detecting the acoustic signals correspond to selected means for detecting the acoustic signals, wherein the second set of means for detecting the acoustic signals correspond to non-selected means for detecting the acoustic signals, and wherein the one or more signals are indicative of the acoustic signals detected by the first set of means for detecting;

means for predicting, based on the one or more signals, an expected blockage of a signal path between a source of the acoustic signals and a first means for detecting the acoustic signals of the first set of means for detecting the acoustic signals; and

means for selecting a particular means for detecting the acoustic signals of the second set of means for detecting the acoustic signals as a newly selected means for detecting the acoustic signals in response to a prediction that the signal path is blocked.

32. The apparatus of claim 31, wherein the multiple receiving means, the means for predicting, and the means for selecting are integrated in a computer.

33. The apparatus of claim 31, wherein the multiple receiving means, the means for predicting, and the means for selecting are integrated in a mobile communication device.

34. The apparatus of claim 31, wherein the multiple receiving means comprise a plurality of microphones, wherein at least one microphone of the plurality of microphones is configured to detect ultrasound signals, and wherein the acoustic signals correspond to the ultrasound signals.

35. The apparatus of claim 31, further comprising means for de-selecting the first means for detecting the acoustic signals in response to predicting the expected blockage.

36. The apparatus of claim 31, further comprising means for determining a location of the source of the acoustic signals based on a time difference of arrival of the acoustic signals at two or more means for detecting the acoustic signals of the first set of means for detecting the acoustic signals.

37. The apparatus of claim 31, further comprising:

means for predicting a travel path of the source based on the one or more signals; and

means for determining the particular means for detecting the acoustic signals of the second set of means for detecting the acoustic signals based on the predicted travel path of the source.

38. The apparatus of claim 31, wherein the multiple receiving means includes at least one microphone configured to detect detect first acoustic signals of the acoustic signals, the

first acoustic signals having a frequency in excess of twenty (20) kiloHertz (kHz), and to detect second acoustic signals of the acoustic signals, the second acoustic signals having a frequency between twenty (20) Hertz (Hz) and twenty (20) kHz.

39. The method of claim **1**, wherein the particular receiver is selected in response to predicting an expected blockage of the first receiver, and wherein selecting the particular receiver of the second set of receivers as the newly selected receiver comprises:

determining a first value associated with a first non-selected receiver of the second set of receivers, wherein the first value is associated with a signal-to-noise (SNR) value; and

determining a second value associated with a second non-selected receiver of the second set of receivers, wherein the second value is associated with a discriminator output of a delay locked loop (DLL) or a phase output of a phase-locked loop (PLL), wherein the particular receiver is selected as the newly selected receiver based on the first value and the second value.

40. The method of claim **39**, wherein predicting the expected blockage of the first receiver comprises:

receiving tracing direction data at a processor from a gesture algorithm unit, the tracing direction data indicative of a direction of travel of the source of the signal; and

receiving configuration data at the processor from a memory, the configuration data indicative of selection states of the first set of receivers and the second set of receivers, wherein the expected blockage of the first receiver is predicted based on the tracing direction data and the configuration data.

41. The method of claim **1**, wherein the expected blockage of the signal path predicted is based on a signal-to-noise (SNR) value, a discriminator output of a delay locked loop (DLL), a phase output of a phase-locked loop (PLL), or a combination thereof, associated with the first receiver.

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